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MORDECAI CUBITT COOKE

(1825–1914)

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WITH PORTRAIT, PLATE I

There is carved upon a certain tombstone in St. Mary's Islington Cemetery at East Finchley, England, the representation of a lowly and obscure plant. The image excites the curiosity of the visitor for it embodies a toadstool. Why, among all the beautiful and ornate members of the Vegetable Kingdom, should the choice fall on such an unattractive member?

Yet this little toadstool, linked with the name of the man resting beneath the tombstone, has a history, and with reverence the interested visitor will remember this. To us the toadstool is a Coprinus, or to be quite scientific, Coprinus micaceus of Fries—and its clump will remind us of the little woodcut which adorns the cover of the "Handbook of British Fungi" of which he, who lies beneath the tomb, was the author—Mordecai Cubitt Cooke, the veteran mycologist and pioneer of British Mycology.

Mordecai Cubitt Cooke's life affords several generations of botanists as well as the present, ample food for thought. His unique training, his phenomenal interest in the natural sciences, his zeal in imparting such interest to the young, his untiring pen and his retiring nature stand out prominently among the characteristics of this remarkable man.

He was born at Horning, Norfolk, England, on the 12th of July, 1825. His father Mordecai Cooke was a member of an old respected Norfolk family which in past times spelled their name Coke. Mordecai—an old semitic name—was a traditional one, which had been in the family for many generations. Mordecai Cooke, senior, was in early manhood connected with the manufacture of bombazine, once a thriving local industry. He married Mary, daughter of William Cubitt, a schoolmaster of the neighboring village of Neateshead. On his marriage he opened a village store,

which is now the Horning Post Office, and it was here that their eldest son Mordecai Cubitt Cooke was born in 1825.

At an early age he went to a local dame's school where he remained until 1834. From there he went to Ilford to continue his education under an uncle, the Rev. James Cubitt, a Baptist minister, who, being learned in classics and mathematics, afterwards became a tutor at the famous Spurgeon's College.

In 1838 young Cooke returned to Horning taking with him from his learned uncle a useful knowledge of ancient languages, algebra, and a love for observations and study of art and science. We then find him attending a local school at Neateshead.

In 1840 he was forced through circumstances to interest himself in the trade of a wholesale draper, to whom he was apprenticed, but this occupation proved heartily distasteful to a young fellow of his natural inclinations. In 1845 he again went back to London. Young Cooke was a romantic youth—in character like certain heroes portrayed by Ibsen, mayhap likest of all to Peer Gynt—impressionable, loving freedom and yearning for knowledge.

At the age of twenty-one he published a volume of verse (I am told of no particular merit) entitled *The Struggle of Freedom and other Poems*.

He interested himself greatly in poetry and literature generally and we find him lecturing and writing thereon; at that time, no doubt, augmenting by these means the meagre income which he earned in his capacity of copying clerk in a solicitor's office.

The next few years the young man spent in the search for some more congenial and permanent occupation. He made himself acquainted with the system of education of Pestalozzi, and for a brief period taught this method as a pupil teacher in an infant school, kept by an uncle and aunt of his, at Stockton-on-Tees.

He then was fortunate in securing an appointment as headmaster of the National Schools at Lambeth, where he remained during the years 1851 1860. He continued with fervour his botanical studies, gained a first class certificate in botany and founded the Society of Amateur Botanists. Here he became acquainted with Worthington G. Smith, another ardent lover of nature, and a botanist of no mean achievement. It is natural that this association led him to become more specially interested in the study of micro-fungi and fungous parasites. During this time he prepared a comprehensive account entitled *A Plain and Easy Account of British Fungi*, of which the fourth edition appeared in 1860.

No doubt, his famous little books for the young, small octavo shilling manuals by "Uncle Matt," evolved during this time too. Cooke loved children to his old age, and his simple language was certainly calculated

to endear his books to the children. From his *Down the Lane and Back in Search of Wild Flowers* his kindly interest in the young is apparent. Charming words are contained in the preface:

"Dear children, this book is for you. I have written it for you, to help you to learn a little more about the wild flowers than you know, and yet not to trouble you with any more hard words than I can help. You love flowers, and so do I, and the more you know of them the better you will love them. I have pointed out the way to Cissy, how she was to find out their little secrets, and what I have said to her I say also to you. If you will follow her to do as she did, you may learn, as she learned, that the most common weed has a story to tell which may be told to a child; that nothing to Him, who made it, is common or unclean; and that wayside weeds have their place to fill and their duty to do in the world if only—

> To comfort man, to whisper hope whene'er his faith is dim;
> For Who so careth for the flowers will much more care for him.

While in Lambeth he made the acquaintance of P. L. Simmonds, author of *Economic Products of the Vegetable Kingdom*, and in 1861 he was engaged by Dr. Forbes Watson of the India Office to catalogue raw vegetable products, and so forth, that were sent to England for exhibition purposes. On completion of this work he was appointed to a post as Botanical Assistant in the India Museum at Fife House, Whitehall, London. During the years from 1862-1868 he acted as Editor to *Science Gossip*.

About 1865 he became actively interested in fungi, no doubt greatly stimulated by Berkeley with whom he became intimately acquainted and later closely associated. Then follow in rapid succession—his energy as it were a pent up flood suddenly released—numerous works from the pen of this "inveterate" writer. *Our Reptiles; Manual of Structural Botany; A Fern Book for Everybody; Manual of Botanic Terms; Rust, Smut, Mildew and Mould.*

In 1872 he commenced *Grevillea*, first published monthly, later on quarterly. This journal of Cryptogamic Botany has a wide circulation and brought Cooke specimens of Fungi from all over the world, and the number of new genera and species described by him was immense. In consideration of his interest in American mycology some singular honours were conferred upon him. The University of St. Lawrence in 1870 gave him the honorary degree of Master of Arts; in 1873 Yale conferred the same honour; and in 1874 New York University made him an honorary LL.D. In 1877 the Linnean Society elected him an Associate, and Mycological Societies all over the world made him an honorary member. In going over this long list it is curious to find that no German Society appears to have likewise honoured Cooke.

In 1880 Cooke's career nearly came to an end; the India Museum was discontinued, and the staff was placed on the pension list, or dismissed. However, in that year appeared the first part of what Cooke termed "the most ambitious work of his career"—a book, the likeness of which in its completeness was never produced in any other country—the *Illustrations of British Fungi*, a monumental work of eight volumes with 1200 plates, completed in 1891. No doubt, this work attracted Sir Joseph Hooker's attention, who asked for the transfer of Cooke's services to the Royal Botanic Gardens, Kew, where he filled the post of first Cryptogamic Assistant until 1893. In 1883 *The Myxomycetes of Great Britain* appeared, an appreciation of Rostafinsky's methods. In 1889 this spirit, roaming and revelling in the natural kingdoms, published his *Toilers in the Sea;* in 1892, *The Vegetable Wasps and Plant Worms;* in 1893, *Romance of Low Life Among the Plants;* in 1894, *Handbook of British Hepaticae*, and *Edible and Poisonous Mushrooms;* in 1895, *Introduction to the Study of Fungi, Talks About Wild Flowers, Botanical Wall Charts for Use in Schools;* in 1906, *Fungoid Pests of Cultivated Plants;* in 1908 *Catalogue and Field Book of British Basidiomycetes for Use of Collectors*, etc., etc., etc.

In 1902 the Royal Horticultural Society conferred on him the Victorian Medal of Honour (V.M.H.), and in 1903 the Linnean Society honoured him with their gold medal.

During his long life he collected and preserved many thousands of fungi and other plants. In 1898 Kew acquired his private collections of some 46,000 specimens. He estimated that he drew over 14,000 figures as illustrations for his various works.

It was during his later years that I became intimately acquainted with this indefatigable man. We met twice monthly at that useful and interesting Institution of the Royal Horticultural Society, its Scientific Committee, which he attended in all sorts of weathers. He was a modest, kind old gentleman with a pronounced sense of humour. Unfortunately during his later years he was unable to work owing to the failure of his eyesight. The vision of one eye became totally obscured by cataract and the other partially so. He resignedly accepted the expert's dictum, saying "I have left my eyes behind in my microscope."

In 1912 through "inadvertence" Cooke's obituary notice appeared. But he remonstrated that this account was exaggerated and premature.

His faculties and his sense of humour remained with him until the very end. On the 19th of October he had a severe heart attack, and passed away quietly and painlessly on the 12th of November, 1914. Thus ended the career of another of our respected and valued pioneers in mycology.

THE LEAF BLOTCH DISEASE OF HORSE-CHESTNUT[1]

V. B. Stewart

With Plates II, III and IV and One Figure in the Text

The leaf blotch disease is the most important malady affecting the horse-chestnut (*Aesculus hippocastanum*) and the common Ohio buckeye (*A. glabra*). The red buckeye (*A. parviflora*) is affected also by a similar disease. The leaf blotch is known in America and Europe, apparently occurring, to some extent at least, wherever the horse-chestnut or allied species are found. It is not observed so commonly in northern Europe as in the southern part.[2] In eastern United States where the horse-chestnut has a wide distribution, the disease is frequently observed and often a large percentage of the foliage on mature trees is affected. In nursery plantings leaf blotch is particularly destructive. Very often, by midsummer, the seedling beds are completely defoliated and the growth of the young trees is greatly retarded.

When the disease has become established in a block of young nursery trees it usually causes considerable damage each year. The affected trees develop more slowly and a longer period of time is required for them to attain a marketable size. Several plantings from seed have been observed which have made practically no increase in size for three consecutive seasons, due to the abundant infections each year. Premature defoliation not only checks the growth of the young trees but apparently the affected trees are less able to withstand the adverse conditions of the winter months; an injury and dying back of the twigs and branches has been known to occur on trees which were badly diseased the previous summer.

SYMPTOMS

The leaves and occasionally the petioles, are affected; the writer has also observed lesions on the immature fruits which were undoubtedly

[1] Acknowledgments. The writer is indebted to Dr. Donald Reddick and Dr. H. M. Fitzpatrick of Cornell University for many suggestions during the progress of the work. Certain material for study was kindly furnished by Prof. H. W. Anderson of Wabash College and by Miss Anna E. Jenkins of the United States Bureau of Plant Industry.

[2] Dr. Otto Appel of Germany and Dr. F. Kølpin Ravn of Denmark while visiting in the United States the past year, informed the writer that they had not observed the leaf blotch affecting the various species of Aesculus in their respective countries.

due to the leaf blotch disease, but this point was never definitely determined. The first indication of the disease on the foliage is a slight discoloration at the point of infection. As the lesion increases in size it becomes more or less irregular in outline and the newly invaded tissue appears water-soaked. Gradually the center of the lesion becomes dark red to brown in color, while the margin shows the yellowish discoloration blending into the green of the healthy tissue; and finally the discolored area becomes dried out and dead (Plate II). The spots may be small or of considerable size involving a large part of the leaf and causing the dead area to curl. Generally minute black specks may be seen sparsely scattered over the lesion and occasionally they appear before the tissue is completely dried out. Oftentimes they are crowded together in a definite area which may be slightly lighter in color than the remainder of the affected tissue. The lesions on the petioles appear in the form of small reddish brown spots which are usually somewhat longer than wide and extend up and down the petiole. The effects of the malady on the petioles is never very serious. The spots on the fruit are similar to those on the petioles; there is no decay of the fruit tissue.

The striking symptoms of the leaf blotch disease are the dark red- or brown-colored lesions which often involve large portions or even the entire leaf. When the disease is very prevalent, especially in nursery plantings, the foliage of the trees appears as if it had been burned over by fire.

ETIOLOGY

The leaf blotch disease on horse-chestnut is caused by a fungous pathogene. Various names have been applied to the fungus. This is due apparently to the lack of knowledge regarding the different stages in the life cycle of the organism and also to the occurrence of the organism on another species of the genus Aesculus.

The first description of an organism causing a leaf blotch disease on a species of Aesculus was by J. B. H. J. Desmazières[3] in 1847. He gave it the name *Phyllosticta Paviae* Desm. This description was based on the pycnidial stage of a fungus which he observed on the living foliage of *Pavia macrostachya* DC., now regarded as a synonym of *Aesculus parviflora* Walt. Later in 1883, Ellis and Everhart[4] described a fungus similar to *Phyllosticta Paviae*, as causing the leaf blotch of *Aesculus hip-*

[3] Desmazières, J. B. H J. Quatorzieme Notice, Sur les Plantes Cryptogames Recemment Decouvertes en Fraoce. No. 48. Phyllosticta Paviae Desmaz. Ann. Sci. Nat. ser. 3, **8**: 32–33. 1847.

[4] Ellis, J. B. and Everhart, B. M. New species of fungi. Phyllosticta sphaeropsoidea. Bul. Torr. Bot. Club **10**: 97. 1883.

pocastanum and gave this species the name *Phyllosticta sphaeropsoidea* E. & E.

Morphologically this fungus is identical with the species described by Desmazières as occurring on *A. parviflora* and in their publication of the North American Phyllostictas,[5] Ellis and Everhart regard *P. sphaeropsoidea* as a synonym of *P. Paviae.* Since that time *Phyllosticta Paviae* has been considered usually as the fungus causing the leaf blotch of the three species *Aesculus parviflora, A. glabra* and *A. hippocastanum.* But from the results of inoculation experiments subsequently discussed the writer is obliged, for the present at least, to regard *P. Paviae* and *P. sphaeropsoidea* as two physiologically different organisms. Ascospores and also pycnospores from affected leaves of *A. hippocastanum* failed to infect the foliage of *A. parviflora.* Although several attempts in the cross inoculation work gave the same results in each case, the writer is not fully convinced that the two so-called species are different.

Saccardo[6] in 1879 observed a Phyllosticta-like fungus on the diseased foliage of *A. hippocastanum* and owing to the minuteness of the fruiting bodies he considered this form a new species giving it the name, *Phyllosticta aesculicola* Sacc. Later Ellis and Martin[7] described a similar fungus found on *A. glabra* and named it *Phyllosticta Aesculi* E. & M., but Ellis and Everhart list *P. Aesculi* as a synonym of *P. aesculicola.* Besides the above named species, *Phyllosticta aesculina,* Sacc., has been described by Saccardo[8] as occurring on *A. hippocastanum.* In his description of *P. aesculina,* Saccardo states that this species differs particularly from *P. aesculicola* in the double size of the spores.

The polymorphic nature of the leaf blotch fungus, especially with respect to the spermagonial stage, has been responsible, apparently, for the numerous species of Phyllostiata mentioned above. The writer has seen no reference in literature to the occurrence of spermagonia in the life cycle of this fungus. Without question the fruiting bodies which led Saccardo to establish the species *P. aesculicola* and also *P. aesculina,* are the spermagonial stage of the leaf blotch fungus. The writer has observed spermagonia on leaves of both *A. hippocastanum* and *A. glabra,* which with relation to size, shape and general characters, are in accordance with

[5] Ellis, J. B. and Everhart, B. M. Phyllosticta Paviae Desm. The North American Phyllostictas, p. 41. 1900.

[6] Saccardo, P. A. Fungi Veneti. Phyllosticta aesculicola Sacc. Mich. 1: 134. 1879.

[7] Ellis, J. B. and Martin, Geo. New Fungi. Phyllosticta Aesculi E. & M. Jour. Myc. 2: 130. 1886.

[8] Saccardo, P. A. Fungi Gallici ser. 6, no. 2261. Phyllosticta aesculina Sacc. Description in Syl. Fung. 3: 3-4. 1884.

Saccardo's descriptions of *P. aesculicola* and *P. aesculina.* Specimens have been examined of the same collection from which type material of *P. Aesculi*, a synonym of *P. aesculicola*, was taken and the fruiting bodies present, on the basis of which the species was established, are similar to the spermagonia found on leaves affected by the leaf blotch fungus.

As previously stated, Saccardo considered *P. aesculicola* and *P. aesculina*, as two distinct species on the basis of spore measurements. *P. aesculicola* is described as having minute, hyaline, oblong spores, measuring 3 to 4 by 0.75μ, while the spores of *P. aesculina* are oblong and hyaline, and measure 9 by 3μ. A large number of measurements of both spermagonia and spermatia on leaves of *A. hippocastanum* and also on *A. glabra*, have been made by the writer. These measurements show a wide variation in the size of the spermatia, ranging from 3 to 9 by 0.75 to 3μ. Frequently the spermatia in the same spermagonium are more or less uniform being either of the large or small type. This was no doubt true in the case of the material on the basis of which the new species were established. On the other hand, both large and small spermatia have been observed in the same spermagonium. Furthermore, both large and small spermatia have been found intermingled with pycnospores of the average size in the same fruiting body.[9]

The spermagonia-like bodies are always found associated with other stages in the life cycle of the leaf blotch fungus. They are similar to a stage regarded as spermagonia in the life cycle of other closely related species of fungi, particularly so of *Guignardia Bidwellii* (Ellis) Viala & Ravaz. The leaf blotch disease of horse-chestnut appears early in the season and only pycnidia with large spores (10 to 16μ by 6.5 to 10μ) are present in the lesions at that time. The spermagonia with minute hyaline spores appear along with the pycnidia and incipient perithecia on leaves infected after the first of August. They have not been observed previous to this time. A spermagonium frequently develops immediately next to and in the same stroma with a pycnidium or perithecium, the two being separated only by a thin membranous wall. This condition would be somewhat unusual if the two fruiting bodies were of different organisms. Also it is not a common occurrence to find spores of two distinct fungi in the same fruiting body as is the case where pycnospores are intermingled with spermatia. All attempts to germinate the spermatia have failed.

On the basis of these facts there seems to be but little doubt that the minute-spore forms are spermagonia of the leaf blotch fungus and not

[9] D. Reddick states (New York (Cornell) Agr. Exp. Sta. Bul. 293:328. 1911) that in case of *Guignardia Bidwellii* it is very common to find pycnospores intermingled with the spermatia in the same fruiting body.

fruiting bodies of different species. It is suggested, therefore, that *P. aesculina* and *P. aesculicola* (*P. Aesculi*) be reduced to synonomy.

The sexual stage of *Phyllosticta Paviae* on *Aesculus parviflora* has never been observed, although in 1887 Brunaud[10] described a minute spore form, *Phyllosticta paviaecola* Brun., as occurring on *A. parviflora*. This form is similar to *P. aesculina* and judging from the different forms studied on affected leaves of *A. hippocastanum* and *A. glabra*, the fruiting bodies of *P. paviaecola* are simply the spermagonial stage of *Phyllosticta Paviae*. It is suggested, therefore, that *P. paviaecola* also be reduced to synonomy.

The ascogenous stage of the leaf blotch fungus was described by Peck[11] from material collected on the dead leaf petioles of *Aesculus hippocastanum*. Peck named the fungus *Laestadia Aesculi* but did not associate it with the pycnidial stage. In the month of May, 1914, the writer found perithecia on diseased horse-chestnut leaves which had been exposed to the weather throughout the winter months. These perithecia were similar to those described by Peck and inoculation experiments proved them to be the perfect stage of the leaf blotch fungus.

In considering the generic name of the fungus, the use of Laestadia as the name of a group of fungi is not permissible owing to the fact that previous to this time, a composite genus of Kunth[12] was given the name Laestadia. Moreover, considerable difficulty arises in placing this fungus in the proper genus on account of the somewhat imperfect classification of the Mycosphaerellae. The fungus fits well with the character of that group of Mycosphaerellae under which the genus Guignardia is included; the perithecia are single, paraphyses absent and the ascospores are one-celled. On the other hand, there is some doubt concerning the validity of the generic name Guignardia. This was pointed out by Reddick[13] in connection with the etiology of *Guignardia Bidwellii* (Ellis) Viala & Ravaz. However, with our present knowledge of the very large and imperfectly understood group of Mycosphaerellae, it appears impossible to determine the validity of the name Guignardia. The writer therefore proposes tentatively at least, the substitution of the name Guignardia for Laestadia, giving **Guignardia Aesculi** (Pk.) nov. comb. as the correct name of the leaf blotch fungus of horse-chestnut.

[10] Brunaud, Paul. Champigons a ajouter a la flore Mycologique des environs de Saintes. Phyllosticta paviaecola Brun. Bul. Soc. Bot. de France, ser. **34**: 430. 1887.

[11] Peck, Chas. H. Plants not before reported Laestadia Aesculi Rept. New York State Botanist **39**: 51. 1885.

[12] Kunth. Lessing's Synopsis generum Compositarum, p. 203. 1832.

[13] Reddick, D. The black rot disease of grapes. New York (Cornell) Agr. Exp. Sta. Bul 293: 289-364. 1911.

DEVELOPMENT OF PYCNIDIA

A few days after the leaf blotch lesions appear on the foliage, numerous pycnidia may be seen somewhat sparsely scattered over the upper surface of the affected area and they also have been observed occasionally on the under side of the leaf. Usually they appear in the older dried out part of the lesion, but frequently are seen nearer the periphery in tissue which is not completely discolored and still contains some chlorophyl. The pycnidia measure from 90 to 175 μ in diameter and have a tendency to be globose in shape. There is a well developed ostiole (Plate III, figs. 3 and 4).

The development of the pycnidium is comparatively rapid. Fixed material from lesions showing the first signs of fruiting bodies gave pycnidia in several stages of development. In microtome sections, stained with iron alum haematoxylin, deeply stained hyphal threads may be noticed in the leaf tissue. The first indications of the pycnidial development is the interweaving of the mycelial hyphae which later anastomose forming a gnarl at some point between two palisade cells of the leaf tissue (Plate III, fig. 1). With increased growth of the fungous cells the adjoining host cells are forced apart and may be even entirely separated with the gnarl extending into the spongy parenchyma. The mycelial threads on the outside of the gnarl anastomose to form a pseudoparenchymatous tissue. But the greatest activities are apparently on the interior and by increased growth from the center the newly formed wall of the pycnidium is pushed out in all directions. At this time the pycnidium becomes noticeable externally by the epidermal cells being slightly pushed up and the cuticle broken. Cross sections of pycnidia in this stage of development show the mycelial hyphae to be less interwoven at the center with a tendency toward more or less radial arrangement as basal cells extending toward the center (Plate III, fig. 2). Soon the basal cells become more definite owing to their increase in length along with the growth of the pycnidium which rapidly attains the normal size. As the hyphal or basal cells reach the center the tips become swollen and more or less subclavate in shape. A constriction soon appears at a point just back of the sub-clavate tip (Plate III, fig. 5) which is finally cut off resulting in the formation of a pycnospore. With the production of large quantities of pycnospores in the pycnidium, space is provided for them by the disappearance of certain of the thin-walled cells on the interior and also by the pressure outward, which tends to push back the thick-walled pseudoparenchyma. In this way a greater cavity is produced within the pycnidium for the newly formed spores (Plate III, fig. 4). With the disappearance of the thin-walled cells on the interior there is

also the formation of the ostiole The writer was unable to determine definitely the method of development of the ostiole in the pycnidium, however, this point was more thoroughly studied in connection with the development of the perithecium subsequently discussed.

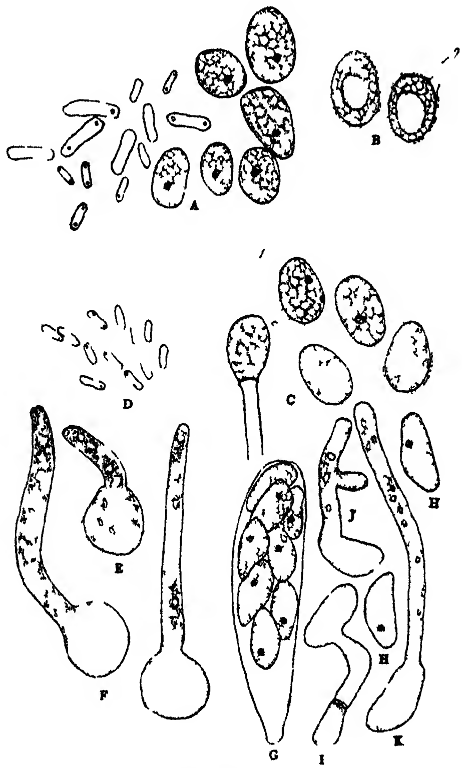

FIG 1 Various spore forms of *Guignardia Aesculi* *A*, Spermatia and pycnospores from the same fruiting body, *B*, Pycnospores with large guttulae, *C*, Pycnospores showing the appendages, *D*, Small-sized spermatia, *E*, Germinating pycnospore with appendage still attached, *F*, Pycnospores, forty-eight hours after germination, *G*, Ascus containing eight spores; *H*, Ascospores, *I*, Germinated ascospore showing formation of appressorium, *J* and *K*, Ascospores forty-eight hours after germination

As the pycnospores are produced they are enveloped in a gelatinous substance which holds them apart With the presence of moisture the gelatinous substance swells and the spores are discharged from the pycnidium through the ostiole. Held together by the gelatinous substance the spores often may be seen extruding from the ostiole as a white coil two or three millimeters in length.

There is considerable variation in the shape of the young pycnospores while in the pycnidium but when discharged and the pressure from all sides becomes more equal they are usually more or less ovoid. Oftentimes however, they are globose or oblong (fig. 1, a). The spores have one and frequently two nuclei and measure from 10 to 16 μ in length by 6.5 to 10 μ in diameter. They are hyaline with a granular content and may be one to two guttulate. Occasionally one large guttula is present as seen in figure 1, *b*. At the apex of the pycnospore there is present a very hyaline appendage which is generally slightly curved (fig. 1, *b* and *c*). The appendage appears to be an extension of the cell wall but is slightly granular and varies in length from one-third to somewhat longer than the pycnospore.

Considerable difficulty has been experienced in obtaining a high percentage of germination of the pycnospores although material from various sources was used. Usually, however, after twenty-four hours, spores in tap water will show the development of a small germ tube (fig. 1, *e*) which increases somewhat throughout the next twenty-four hours. The writer has seldom observed germ tubes of much greater length than those shown in figure 1, *f*. It is presumed that artificial conditions are not conducive to the production of germ tubes of any great length.

SPERMAGONIA

The spermagonia (Plate IV, fig. 10), have never been found previous to the month of August and they are less abundant as compared with the number of pycnidia. Usually they are most common after the first of September. At this time the spermagonia are more noticeable, especially on account of the fact that a large percentage of the pycnidia are void of spores. Under such conditions one might readily assume the spermagonia and pycnidia to be fruiting bodies of two different organisms. Of the several species of Phyllosticta described on Aesculus on the basis of this minute spore form, September has been, in each case, the date of collection of the type material.

The general scarcity of spermagonia in affected leaves has not permitted a thorough study of the development of these fruiting bodies. However, the few stages which have been observed indicate that the development is similar to that of the pycnidia. In several cases, as previously stated, the spermagonium has been found developing in the same stroma with a pycnidium or incipient perithecium (Plate IV, fig. 13), the two bodies separated only by a thin membranous wall. There is a wide variation in the size of the spermagonia which measure from 40 to 110 μ in diameter. They occur both on the upper and lower side of the leaf.

Within the spermagonium are developed large quantities of spermatia which are abstricted from the tips of basal cells or conidiophores and extruded through a well-developed ostiole (Plate IV, fig. 10). The basal cells of the spermagonia are much longer and not so blunt as those in the pycnidia. Frequently where a pycnidium and spermagonium develop in the same stroma, the membranous wall may be broken and pycnospores are found intermingled with spermatia. On the other hand, in some cases the two kinds of spores may be found in a single fruiting body which apparently has no connection with another.

The mature spermatium is oblong, hyaline and usually very minute, however, a wide variation in size has frequently been noticed. Spermatia from the same fruiting body intermingled with pycnospores show a variation in measurement from 3 to 9 μ in length by 0.75 to 3 μ in diameter (fig. 1, *a*). When seen in a liquid mount the spermatia appear to be somewhat enlarged at the ends, that is, dumb-bell shaped (fig. 1, *d*). This is due to the dense refractive protoplasmic content at these points. An effort has been made to germinate the spermatia both in tap and rain water but all attempts proved futile.

DEVELOPMENT OF PERITHECIA

Diseased horse-chestnut leaves collected September 10, 1914, showed numerous pycnidia-like fruiting bodies scattered over the affected area. On examination with the microscope a few of these were found to contain pycnospores but in most cases no spores had developed and the interior was filled with large pseudoparenchymatous cells which contained a white granular substance. These observations suggested a similarity between the leaf blotch fungus of horse-chestnut and *Guignardia Bidwellii* (Ellis) Viala & Ravaz., which causes the black rot of grapes. Further studies showed the pycnidia-like fruiting bodies to be incipient perithecia which Reddick[14] has designated as pycnosclerotia (Plate IV, figs. 11, 12, 13).

Soon after the middle of August following the appearance of the spermagonia, the incipient perithecia are found in the affected leaves. These are produced almost exclusively at this time instead of pycnidia, although a few pycnidia, bearing pycnospores, usually are present also. The development of the perithecium is similar to that of the pycnidium except that no basal cells are produced, the whole interior being filled with pseudoparenchyma of thin-walled cells. Sections of the young perithecium stained with iron-haematoxylin and counter-stained with Congo

[14] Reddick, D. The black rot disease of grapes. New York (Cornell) Agr. Exp. Sta. Bul. 293: 289-364. 1911.

red, show the dark, thick cells of the outer wall, with the reddish tinted thin-walled cells on the interior, some of which, near the center retain the haematoxylin stain more tenaciously (Plate IV, figs. 11 and 12). In the upper portion of the perithecium which protrudes slightly above the epidermis of the leaf, there is a wedge of tissue, cellular in appearance, which extends from the outside through the outer wall (Plate IV, fig. 11). Apparently this wedge is of the same origin as that which forms the thick pseudoparenchymatous tissue of the outer wall and differs from this tissue only in being thinner walled. The cell-like cavities are practically void of contents and the walls stain deep blue in contrast to the tissue on the interior of the perithecium in which the red stain predominates. In some cases the wedge of tissue is seen to protrude somewhat beyond the outer wall of the fruiting body (Plate III, fig. 6). After the formation of the perithecium to this point there is practically no further development until late winter.

Undoubtedly the weather conditions exert a considerable influence as to the time further activities are apparent in the perithecium, but material exposed to the weather throughout the winter months shows some development in late February and March, particularly with respect to the ostiole. Some of the cavities in the outer portion of the wedge appear to be breaking down and the tissue in this region is somewhat disorganized (Plate IV, fig. 12). With further development of the perithecium the disintegration of this tissue continues from the outside inwardly. The extent of disorganization is often sharply delimited as seen in Plate IV, figure 13. The lower portion of a layer of tissue is still intact and forms a definite line across the opening in the incipient perithecium. Finally the wedge disappears entirely leaving an opening through the outer wall; the complete disappearance of the wedge, however, may not occur until the asci are almost mature (Plate III, fig. 7). The complete formation of the ostiole results in the disappearance of the tissue on the interior which nourishes the ascogenous cells, subsequently discussed.

When activity begins in the formation of the ostiole some of the deeply staining cells in the center of the perithecium begin to elongate and push upward. These are the ascogenous cells (Plate IV, fig. 14), which number sixty or more in each perithecium. The development of all the ascogenous cells is not simultaneous and at first only a few may begin to elongate. Gradually as the season advances more of the cells become active and with their development there is a disappearance of the surrounding thin-walled cells which apparently serve as nourishing tissue for the ascogenous cells. After a considerable elongation a single well-defined nucleus appears near the center of each cell (Plate IV, fig. 15). The cell soon becomes more obtuse at the apex and with further develop-

ment it assumes the shape of the mature ascus (Plate IV, fig. 16). Up to this point the development is somewhat gradual depending upon the conditions; material examined March 10, 1915, showed the ascogenous cells about one-half to two-thirds the size of the mature ascus, but owing to the sudden fall in temperature accompanied by snow fall there was no further development when specimens from the same material were examined three weeks later. On the other hand, the transition from the uninucleate stage to the formation of the ascospores is very rapid.

It has been difficult to obtain intermediate stages. All of the material examined shows either the single nucleus in the ascus or the eight uninucleate ascospores more or less definitely outlined (Plate III, fig. 8). The transition from the uninucleate condition is evidently dependent upon weather conditions in the spring which are conducive to the maturation of the asci.

The mature ascus is subclavate in shape and the eight ascospores are somewhat crowded together toward the apex (fig. 1, *g*). There is considerable variation in the size of the asci, depending upon the conditions under which they are examined. In a dry mount the ascus measures 54 to 70 by 15 to 17 μ, but asci mounted in water have been observed which measured 98 μ in length. The significance of moisture is appreciated more in considering the discharge of the ascospores from the perithecium.

Frequently, when perithecia are mounted in water, asci may be seen protruding through the ostiole. The elongation of the ascus is due to the absorption of water and the subsequent gelatinization of the ascus wall which becomes almost invisible. With the protrusion of the ascus the ascospores are crowded together near the apex. Soon a slight movement is manifest by the distal spore which forces its way through the apex of the ascus and is violently ejected. There is no evidence of a pore by means of which the spores could pass out of the ascus. They apparently are forced through the gelatinized wall. With the ejection of the first spore the process continues rapidly and within a period of ten to thirty minutes, the ascus may be emptied of spores. The discharge of the spores is apparently in accordance with conditions favorable for infections of the newly developed foliage on the host plant in the spring.

The ascospores (fig. 1, *h*) are subelliptical, uninucleate, and have a granular content. They vary in size from 12 to 18 by 7 to 9 μ. Considerable difficulty has been experienced in obtaining germination of the ascospores. Various methods have been used but the percentage of germination is relatively low. In figure 1, *j* and *k*, is shown germinating ascospores after forty-eight hours; germ tubes of a greater length have never been observed. Frequently appressoria (fig. 1, *i*) are formed when the spores are allowed to germinate on the surface of agar.

MYCELIUM IN THE TISSUE

The incubation period of ascospore inoculations is from ten to twenty days. After the infection appears the development of the water-soaked lesion is rapid. The mycelium in newly invaded tissue is hyaline, septate, somewhat granular and irregular, and it varies from 2 to 4.5 μ in diameter. It is both inter- and intracellular and branches profusely, but no haustoria have been found. The mycelial hyphae which ramify the tissue attacked, cause a necrosis of the cells. In Plate IV, figure 9 is shown a cross section of a leaf through the edge of a leaf blotch lesion. A sharp line of demarcation separates the healthy tissue from the diseased area. The cells of the mesophyll and of the palisade layer are shrunken and dried out so that at some points they are hardly recognizable as cells. The affected tissue, however, remains intact. There is no enzymic action on the middle lamellae, causing the cells to separate and the tissue to disintegrate.

CULTURAL STUDIES

Petri dishes containing a thin layer of agar may be inverted over moist bits of leaves bearing perithecia and when the spores are ejected from the asci they lodge on the agar surface above. The greatest number of ascospores are obtained when the bits of leaf are not more than one-half centimeter from the agar, but a few spores may reach the agar when it is about one centimeter from the leaf. Very few of the spores which were secured in this way have germinated and in no case has a mycelium been developed. By examining the plates of agar from the under side with a low magnifying microscope, an occasional germ tube may be seen and frequently after a slight germination an appressorium is formed. No further development has been observed although various kinds of agar were used including nutrient agar and agars containing decoctions of horse-chestnut, oats and potatoes. A pure culture from an ascospore was finally obtained by transferring a single germinated spore on a small piece of agar to a test tube containing a sterilized horse-chestnut leaf petiole.

The fungus which developed from the single ascospore on the leaf petiole was similar to that isolated from an infected horse-chestnut leaf that contained mature pycnidia of the fungus. Later when transfers were made from the culture on the sterilized leaf petiole, to test tubes containing either sterile bean pods or oat agar, the fungus made a very satisfactory growth. Potato agar did not prove a favorable medium for the fungus. The cultures from the ascospore and also from the diseased leaf, consisted of a black mycelial growth with the development of small sclerotia-like bodies which were about one millimeter in diameter. Although the fungus

from the two sources was cultured for a period of twelve months on various media, no fruiting bodies ever developed. Apparently the media and conditions were not suitable for the formation of fruiting bodies.

INOCULATION EXPERIMENTS

On May 10, 1914, ascospores were obtained by inverting plates of agar over bits of horse-chestnut leaf bearing mature perithecia. Under sterile conditions the numerous spores were scraped from the agar surface and transferred to the leaves of two horse-chestnut seedlings growing in the greenhouse. The two inoculated seedlings and two others for check plants were then placed in a large moist chamber for four days. After twelve days numerous lesions were apparent on the leaves of the seedlings which had been inoculated. The affected areas soon appeared discolored and water-soaked and later turned reddish brown, characteristic of the infections of the leaf blotch disease. On June 2, pycnidia bearing mature pycnospores had developed on the lesions. The pycnidia and pycnospores appeared to be identical with the Phyllosticta stage of the leaf blotch fungus. The two check plants remained healthy.

Practically the same results were obtained when this experiment was repeated in the spring of 1915.

CROSS INOCULATIONS

On May 27, 1915, ascospores from perithecia in leaves of *Aesculus glabra* were ejected under sterile conditions onto inverted plates of agar. Ascospores were also obtained by crushing perithecia from leaves of *A. glabra* in a drop of sterile water. The two quantities of spores were kept separate and used for inoculating seedlings in the greenhouse. One *Aesculus glabra* seedling and two *A. hippocastanum* seedlings were inoculated with the spores crushed from the perithecia. Two *A. glabra* and two *A. hippocastanum* seedlings were inoculated with the spores which were scraped from the plates of agar. One *A. glabra* and two *A. hippocastanum* seedlings were used as checks. All the seedlings were placed in a moist chamber for five days.

On June 6, several of the leaves showed signs of infection and four days later lesions of the leaf blotch disease were apparent on all of the inoculated seedlings. Young pycnidia were present July 15 and when again examined June 24 mature pycnospores were found. The check plants remained healthy.

Infections have also been obtained by inoculating *A. glabra* seedlings with ascospores from *A. hippocastanum* leaves. This indicates that both of the species of Aesculus are attacked by the same organism.

Owing to the scarcity of the species *Aesculus parviflora*, it was difficult to find material suitable for inoculation work. Only a single mature bush of this species was available.

On May 4, 1915, ascospores crushed from perithecia on *A. hippocastanum* leaves were placed on moistened leaves on three shoots of the *Aesculus parviflora* bush. The shoots were then covered with large test tubes and the opening at the bottom of the tubes plugged with moist cotton. Two shoots were covered with the test tubes for checks. At the same time two *A. hippocastanum* seedlings in the greenhouse were inoculated with ascospores from the same source. The inoculated seedlings and one check plant were then placed in a large moist chamber for three days. The test tubes were removed from the *A. parviflora* shoots after three and one-half days. On May 21 several lesions were apparent on the inoculated horse-chestnut seedlings, but no infections ever appeared on the *Aesculus parviflora* leaves. All the checks remained healthy.

On July 31, 1915, pycnospores from infected *A. hippocastanum* leaves were placed on the moist leaves of two *A. parviflora* shoots. The inoculated shoots were then covered with large test tubes plugged at the bottom with moist cotton. One other shoot was covered for a check. Two *A. hippocastanum* seedlings, growing outside, were inoculated also with pycnospores from the same leaves. The two seedlings and one check plant were covered with lamp chimneys plugged at the top with cotton. Five days later all of the lamp chimneys and large test tubes were removed. When examined August 15, both of the inoculated *A. hippocastanum* seedlings were infected and young fruiting bodies were apparent on August 21. None of the inoculated *A. parviflora* shoots became diseased and all checks remained healthy.

One other attempt was made to inoculate the leaves of *A. parviflora* with pycnospores from diseased foliage of *A. hippocastanum* but no infections were produced. The cause of the failure of these cross inoculations was not determined, but several possibilities suggest themselves: Possibly the two fungi on *A. parviflora* and *A. hippocastanum* are specifically different; or there may be different strains of the same fungus which are limited in their attacks on the various host plants; the question of technique is also of importance. The method of inoculation was practically the same, except that for the *A. parviflora* shoots it was almost necessary to use the large test tubes for moist chambers, their length of about thirty-two centimeters being a big advantage in covering a sufficient amount of the foliage. In considering these points along with the results obtained the experiments appear to be worthy of repetition.

CONTROL

Dusting with sulfur or spraying with either lime-sulfur solution or bordeaux mixture are effective in controlling the leaf blotch disease. Dusting with sulfur is preferable as the dense foliage, especially of horse-chestnut trees, can be more thoroughly covered.

In the nursery, especially the small seedlings, the greatest damage is caused by the ascospore infection early in the spring, before the foliage is fully developed. Leaves which are near the ground suffer more severely at this time than the foliage of mature trees. The greatest injury to large trees is caused by the secondary infections from pycnospores during June and July. For nursery stock, therefore, the first application should be made to prevent the ascospore infections and large trees should be treated soon after the foliage is fully developed. There is practically no secondary growth and relatively little new foliage is developed during the summer on the horse-chestnut trees. For this reason, about three or four applications of the dust mixture at intervals of three to four weeks should be sufficient to control the disease.

A dust mixture of ninety parts finely ground sulfur and ten parts powdered arsenate of lead has proved very effective. The dust is preferable also to the lime-sulfur solution, from the fact that in attempting to thoroughly cover the dense foliage with the spraying solution, the trees often are drenched causing injury by burning. However, lime-sulfur solution, one part to fifty gallons of water is effective in controlling the fungus on well sprayed foliage.

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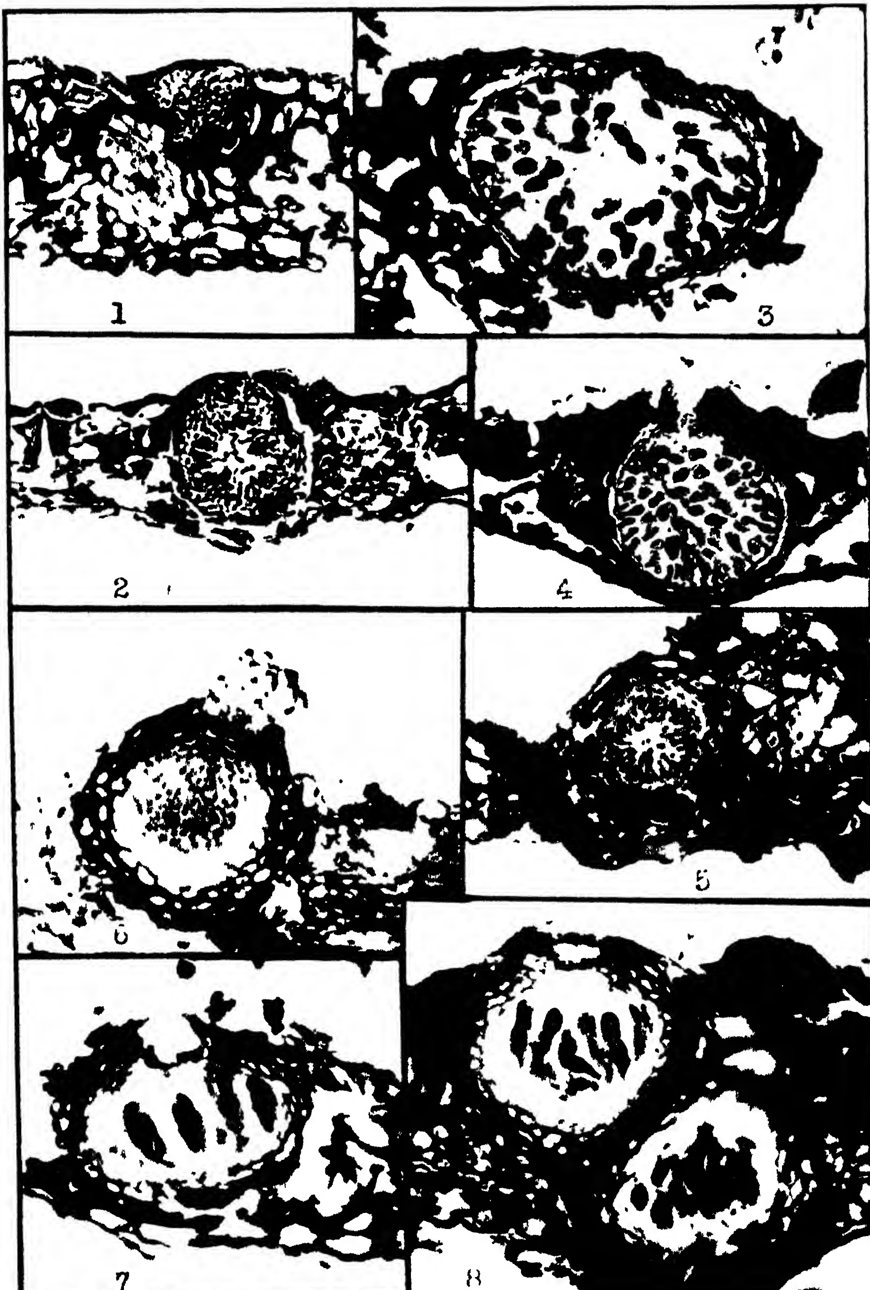


STEWART: LAESTADIA AESCULI

Explanation of Plate IV

Fig. 9. Section of horse-chestnut leaf showing healthy and diseased tissue. Magnified 240 times.

Fig. 10. Spermagonium of *Guignardia Aesculi*. Some of the spermatia have been extruded through the ostiole to the outside. Magnified 240 times.

Fig. 11. Incipient perithecium with deep staining cells in the center. Material fixed September 15, 1914. Magnified 240 times.

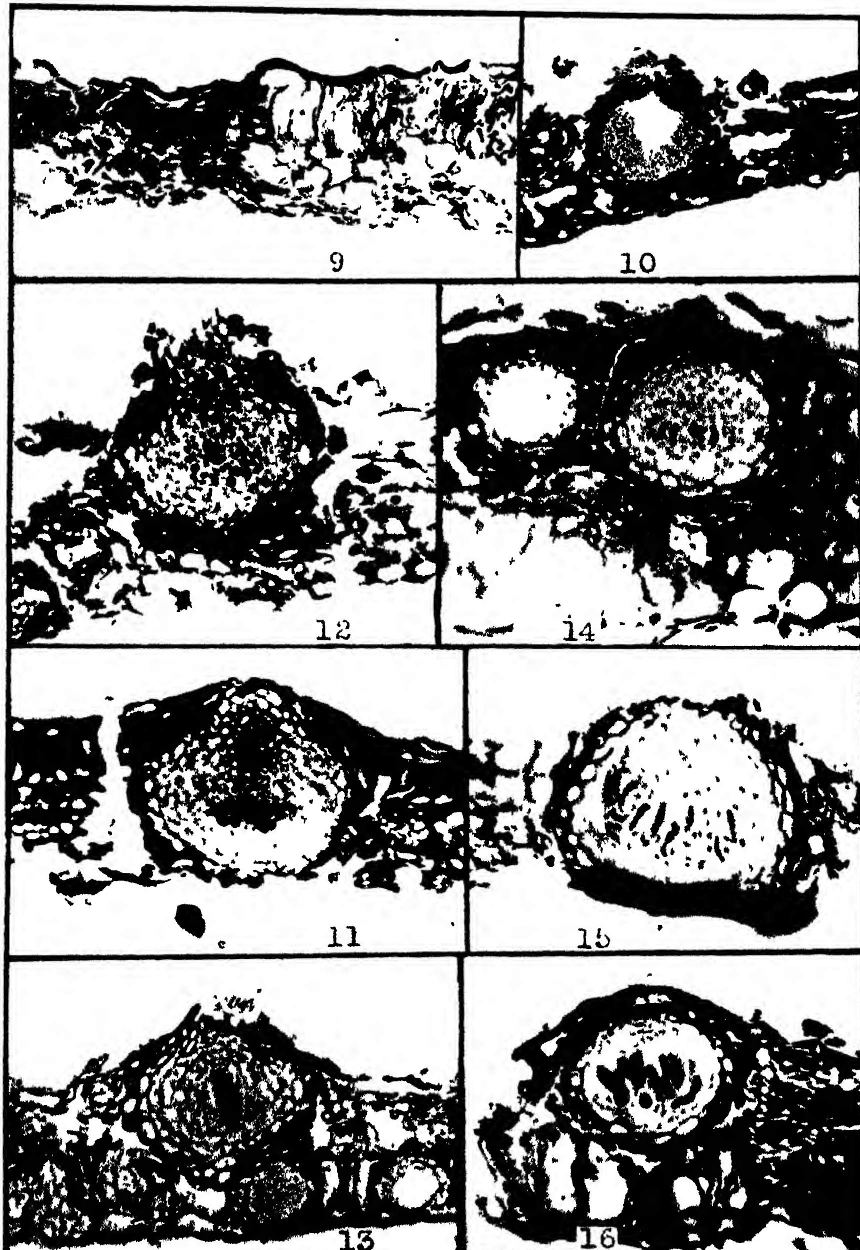
Fig. 12. Young perithecium showing disorganization of the wedge of tissue in the formation of the ostiole. Material fixed February 3, 1915. Magnified 240 times.

Fig. 13. Young perithecium showing formation of the ostiole also with spermagonium in the same stroma as the perithecium. Material fixed February 18, 1915. Magnified 240 times.

Fig. 14. Perithecia, one with very young asci. Material fixed February 26, 1915. Magnified 240 times.

Fig. 15. Perithecium with asci slightly more advanced than those in figure 14. Some of the asci show a single nucleus. Material fixed March 20, 1915. Magnified 240 times.

Fig. 16. Perithecium with immature asci. Magnified 240 times.



STEWART: LAESTADIA AESCULI

2\. OBSERVATIONS ON THE PATHOLOGICAL MORPHOLOGY OF STINKING SMUT OF WHEAT

MORTIER F. BARRUS

WITH THREE FIGURES IN THE TEXT

The writer has had an opportunity to watch the development of plants in experimental plats relating to the control of stinking smut of wheat caused by *Tilletia foetens*. Soon after the plants were headed out a determination of the percentage of affected plants was made and in doing this some peculiar characters of the smutted plants were brought forcibly to the writer's attention. There is so much difference in size and color of heads, and in the flowering parts that there can be no mistaking affected plants for healthy ones. The writer never having observed many of these differences nor having had them called to his attention by anything he had read, was led to make and to present here the following observations.

A careful study was undertaken at the time the plants were in bloom (June 14) and continued until harvest time but for the stages preceding blossoming it was possible to secure material from plants at the margins of the plats and from those growing in the shade in which places the development had been delayed. The symptoms of the various parts as they appeared at different stages in the development of the heads are here recorded.

The seed wheat used for the experiment was a white variety of *Triticum vulgare* similar to Dawson's Golden Chaff and contained 40 per cent of smutted kernels. The plots were heavily seeded on stony ground and were not fertilized. As a result the wheat produced in most cases but a single fruiting culm to the seed and the heads probably are shorter than they would have been under more favorable conditions for growth.

CONDITION PRIOR TO EMERGENCE OF HEAD

Observations were made at a period of about three days prior to the emergence of the head from the upper leaf sheath. At this time no difference between healthy and diseased plants can be observed, so far as the appearance of the heads or the florets are concerned. An examination of the flowering parts, however, reveals striking differences. The pistil of the diseased flower is much larger than a healthy pistil and the

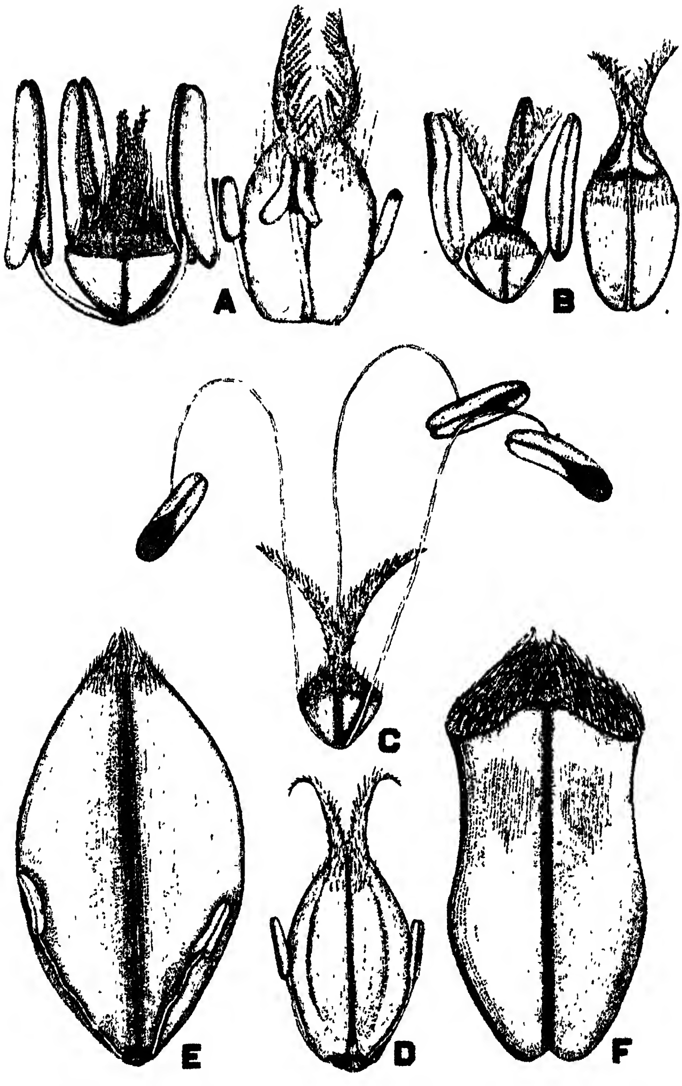


FIG. 1. Healthy and diseased flowers, and kernels of wheat. *A*, Flowers about three days before head should appear; at the left, from healthy floret, ventral aspect; at the right, from smutted floret, dorsal aspect; *B*, flowers just following emergence of entire head; at the left from healthy floret, ventral aspect; at the right, from smutted floret, dorsal aspect; *C*, flower from healthy floret soon after stamens are extruded; *D*, flower from smutted floret at about the same period of development as in *C*; *E*, smutted kernel and two aborted stamens at about the same period of development as in *F*; *F*, healthy kernel about six days after pollination. *A* is enlarged 75 diameters and *B*, *C*, *D*, *E*, and *F* are enlarged 7.5 diameters.

ovary itself is nearly twice as long and somewhat broader than a healthy ovary (fig. 1, *a*). This greater length gives the affected pistil a different shape. The stigma of the diseased pistil is a little further developed and is more spreading than is a healthy one of the same age. One marked difference is the green color of the diseased ovary in contrast with the almost white color of the healthy one. Freehand sections of a diseased ovary show normal cells in the pericarp but the ovule is filled with the spores of the fungus which at this stage have light-colored walls and so pass unobserved to the naked eye when the ovary is crushed.

The stamens of affected flowers are much reduced in length and breadth and the anthers have a pale yellow color which contrasts strikingly with the pronounced green color of healthy anthers. The anther on the dorsal side of an affected pistil is usually elevated more than the two others and the long slender filament fits snugly in the groove of the pistil on that side (fig. 1, *b*). The lobes at the base of this anther are usually spread apart farther than those of the others giving it a peculiar straddling appearance (fig. 1, *a* and *b*). The pollen grains found in anthers from diseased flowers examined in this and later periods of development are pale-colored collapsed structures containing little or no protoplasm.

CONDITIONS FOLLOWING EMERGENCE OF HEAD

Diseased and healthy heads are easily differentiated just after the emergence of the entire head as the former have a blue-green color and the latter have a yellowish green cast. The diseased heads are also slimmer and one can detect at this time the foetid odor so characteristic of this smut. An examination of the flowers shows that growth has taken place in both diseased and healthy pistils but has been most active in the diseased ovary. The difference in color of diseased and healthy ovaries and anthers remains as described earlier. A section of the diseased ovary shows that the spore mass has turned dark so as to enable one to detect it with the naked eye. The spores readily drop out of free-hand sections. The green color of the smutted pistil is found to be due to chloroplastids in all cells of the wall of the ovary except the innermost and outermost layers. A section of healthy ovary shows that the cells containing chloroplastids are confined to a single layer in the ovary wall adjoining the innermost and colorless layer and to other cells near the sinus. The anthers of healthy flowers still have a green color and are about twice the size of anthers of diseased flowers (fig. 1, *b*).

CONDITION AT BLOSSOMING TIME

At blossoming time the difference between diseased and healthy plants is apparent. The diseased plants have shorter culms and diseased heads

are usually shorter and much slimmer, being smaller in both diameters. An examination of a large number of heads will enable one to find occasionally an affected head that is as long and as broad as healthy heads; on the other hand, healthy heads are sometimes found that are as short and as slim and are borne on as short culms as affected heads. Edler[1] observes that Squarehead wheat when affected with stinking smut produces heads much longer and looser than is normal. Appel[2] confirms these observations and believes this condition of the smutted plant is a reversion to the original type. Miczynski[3] found a lengthening and loosening of heads of several varieties of *Triticum compactum* when infected by *Tilletia tritici*. Sperling,[4] while confirming the observations made on Squarehead wheat, found that stinking smut affects bearded wheat (Rauhweizen) less often and then does not cause the lengthening and loosening of the head as observed on Squarehead. In fact, it is difficult, he says, for anyone except an expert to tell the difference in appearance between smutted and healthy heads. Diseased heads still have the blue-green color which gives them an immature appearance as does also the absence of extruded stamens which are so conspicuous on healthy heads (fig. 2, *a*).

An occasional diseased head is found of which the upper portion has died, the dead portion usually being curled and twisted. A few diseased heads are found on which the upper two or three spikelets, and in a few cases an occasional one farther down, contain healthy florets. One head shows only healthy spikelets on one side and only smutted ones on the other. Several cases were noticed at the margin of the plat where some plants had stooled in which one or more healthy heads were found in a stool with smutted ones but more often all heads were smutted or all healthy.

While it cannot be considered a constant character numerous affected culms show a peculiar twisting of the upper leaf and sometimes of the leaf below. This twisting is similar to that observed frequently on wheat culms affected with loose smut.

An examination of the flowers at blossoming time showed much the same conditions as noted earlier except that the anthers of healthy flowers

[1] Edler, W. Einwirkung des Frostes auf den Squarehead-weizen. Illust. landw. Zeit. 1903, No. 60 Cited from Edler, W. Zur veränderlichkeit des Squarehead-zuchtern. Fühling's landw. Zeit. **55**: 601–606. Figures 1–2, 1906.

[2] Appel, O. Zur Beurteilung der Sortenreinheit von Squarehead-Weisenfeldern. Deut. landw. Presse **1906**: 465–466. Figure 1.

[3] Miczynski, K. Der Einfluss des Steinbrandes auf die Form der Weizenähren. Zeits. landw. Versuchs. in Oesterreich **1911**: 232–235. Figure 1.

[4] Sperling, E. Der Einfluss des Steinbrandes auf die From des Weizenähren. Illust. landw. **32**: 865. 1912.

had now a yellowish color. At least one floret of each spikelet had extruded its anthers by means of a rapid elongation of the filament (fig. 1, *c*). The stigma was fully expanded and in case of those flowers in which the anthers had been extruded, the stigma bore many pollen grains. The anthers of diseased flowers (fig. 1, *d*) had not changed in size and color from that described earlier.

FIG. 2. Healthy and diseased heads of wheat. *a*, Two smutted heads (left) and one healthy head, at blossoming time. The extruded anthers are conspicuous in the healthy head. Natural size. *b*, Side view of healthy (left) and smutted heads of wheat near time of maturity. Natural size. *c*, Back view of healthy (left) and smutted heads at same stage as is shown in *b*. The healthy heads in both cases are larger. Natural size.

CONDITION FIVE TO SIX DAYS AFTER BLOSSOMING

Five to six days after blossoming the slim condition of affected heads is not so noticeable. Many are just as plump as healthy heads and might be mistaken for them except for their blue-green color. This plumpness of the head is especially noticeable when viewed so as to expose the side of the spikelet which has become somewhat expanded due to the increasing plumpness of the diseased kernel. In such cases the side aspect of an affected head is as broad as the healthy head while the front aspect is narrower.

While affected culms can be found at this time which are as tall as healthy ones, in general the healthy heads stand highest This greater height is not due to the greater length of any particular internode. Often all

FIG. 3 Fifty healthy and fifty smutted kernels at maturity Natural size.

internodes share in the elongation. In the case of wheat plants affected by loose smut where mature culms are shorter than healthy ones, the difference is due to the failure of the upper internode of affected plants to develop as much as healthy ones do.

In healthy florets the empty and shrunken anthers have fallen or are entangled in the withered stigma. In diseased florets they are either carried upward with the growth of the ovary, the filaments being broken and shriveled, or remain below and attached to the filaments. In several cases the dorsal anther was located near the top of the ovary, the others being below the middle.

The healthy kernel is grayish white in color with a small amount of green showing in the sinus on the ventral side. It is shield shaped, the flattish top being covered with hairs and the withered stigma. The diseased kernel is dark green in color, its sinus very shallow, and it has a

plumper appearance than healthy ones. It is tapering at both ends, the withered styles completing the point at the top. The size of the two kernels is much more equal than they have been before, although the smutted one has greater equatorial diameter and is a little longer (fig. 1, *e* and *f*).

CONDITION NEAR MATURITY

As plants are nearing maturity (July 15) the field has a golden appearance and an examination shows that the healthy kernels are in the pasty stage. Healthy heads have a greenish yellow or golden yellow color, depending upon their ripeness. Green streaks appear at tip and margins of outer glumes and lemmae and at the margin of paleae. Powdery mildew is present on many heads and may affect somewhat the color of the heads at this time.

The smutted heads look much greener than the others, the golden color possessed by healthy heads being absent. The outer glumes are green, the lemmae are greenish white with an occasional tinge of yellow and the paleae are green at their margins. Many affected heads have a dead appearance due to the yellowish brown color of paleae and lemmae particularly at the apex. This may be due in part to the mildew. The enclosed anthers are plainly visible through the transparent paleae. The kernel is still quite green although a yellowish white color shows at the apex and along the sides. The apex of the kernel shows in most affected heads because of the spreading glumes. Culms of both healthy and of diseased plants have a yellowish green color.

The side of heads of smutted wheat is about the same width as healthy heads but the front aspect of healthy heads is wider. The contrast in color is greatest when the front or back of heads is seen. The angle of divergence of glumes is about equal in diseased and healthy heads (fig. 2).

The smut mass in the kernels has a mouse-brown color and is pasty. Beetles have been feeding upon it for the past two weeks.

CONDITION AT MATURITY

Observations made after the wheat has been cut and cured shows little difference from what was observed as wheat was approaching maturity. Fifty smutted heads were measured. The average dimensions were 8.4 by 12 by 69.2 mm. as compared with 9.5 by 12.7 by 74.4 mm., the average for fifty healthy heads. The heads and all flowering parts of both healthy and smutted plants have lost all green color previously observed. The healthy kernels have a golden yellow color and a deep sinus. The smutted kernels are gray or gray-brown in color and have a

shallow sinus. The dry anthers can still be found enclosed with the smutted kernels. Affected kernels when broken reveal a dry caked, nearly black mass of spores which can be easily crushed to a powder. One is surprised to find at this time that the smutted kernels are smaller in all diameters than are healthy ones. Measurements of more than a hundred smutted kernels gives an average of 2.6 mm. for one diameter, 2.3 mm. for the other, and 5.1 mm. for the length. One hundred healthy kernels average in the same order 3.1 by 2.6 by 6.1 mm. (fig. 3). With the idea that there might be less difference between diseased and healthy kernels when swollen with water, measurements were made of twenty smutted and twenty healthy kernels that had been soaked in water for one day. Under these conditions the average dimensions for the diseased kernels were 2.8 by 2.6 by 5.4 mm. and for the healthy ones 3.3 by 2.8 by 6.5 mm. While all have swollen from 0.2 to 0.4 mm. the proportion between healthy and smutted is practically the same as before.

For heads of equal length there are more smutted kernels in a smutted head than healthy kernels in a healthy head. This is due to the formation of four and sometimes five smutted kernels in many of the spikelets. There are rarely ever less than three such kernels except on the small lower spikelets where the corresponding spikelets on healthy heads are sterile.

The specific gravity of smutted kernels is much less than healthy ones which condition is made use of in removing smutted kernels from healthy ones in seed treatment.

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3.

SOME BARK DISEASES OF CITRUS TREES IN FLORIDA[1]

J. G. Grossenbacher

With Nine Figures in the Text

Citrus trees, like other plants, are subject to various ailments. These become evident in poor, abnormal growth, or as localized injuries on the leaves, twigs, fruit or bark. Some of these troubles are due to certain organisms, others appear to result from adverse conditions of the environment. Many of the diseases which are primarily due to fungi may be prevented by covering the parts likely to become infected with some fungicidal substance, of a kind and strength that is not injurious to the cultivated plant. The treatment or prevention of troubles which are chiefly due to an adverse environment is still in a rather primitive state, because we know too little about the conditions necessary for the required development of the more or less modified plants that we have evolved through selection and culture.

In most of the citrus growing sections of Florida there is sufficient rainfall for good tree-growth, but in some places a water shortage may prove more or less injurious during certain seasons of the year unless the need is met by irrigation. Since water passes very rapidly through the sandy soils, its relative availability to citrus trees, during most of the time, depends chiefly upon the level under a grove, of the uppermost layers of perennially moist soil. In some places the water-table may be too high for good tree-growth, as is often the case on flatwoods land and on land reclaimed from swamps. It is a well known fact that the shoreline or water-level of the numerous lakes may vary greatly from year to year or from season to season. This variation which indicates a change in the height of the water-table in the ground, often amounts to several feet and probably has a marked influence on the growth and bearing capacity of citrus trees.

This effect of the variation in the water-supply is marked in regions where the subsoil, to considerable depth, consists mainly of coarse sand and where,

[1] This paper is a generalized summary of detailed investigations carried on along the different lines. Since the purpose of the paper is to give a brief general view of the subjects, the various details regarding the making of numerous isolations, inoculations, and microtome sections of affected tissues, are not included. The results obtained are given only in general terms.

even in rainy seasons, the water-table is far below the surface; but it is especially noticeable in localities where a layer of clay or some other partially impervious material near the surface sustains a temporary water-table during a portion of the year. The water above such a shallow layer is exhausted during a drought and the impervious nature of the layer hinders the rapid upward movement of water from deeper layers, thus inducing severer droughts than occur on soils with a lower water-table. In both of these types of localities irrigation is profitable, and in the latter dynamiting would probably aid in equalizing the water supply in that the rapid downward and upward movement of the soil water is aided by breaking up the hardpan.

The most uncertain and doubtless the most farreaching environmental factor influencing the citrus industry in Florida is temperature. As a matter of fact, the occurrence of occasional periods of low temperature at unseasonable times is not only the factor limiting the extent of the business, in that trees may be killed to the ground over night, but it is responsible for some slighter bark injuries which occur during the more moderate cold snaps, that are of more frequent occurrence. These injuries often result in localized bark diseases.

That marked variations in the water supply and untimely cold snaps influence the health of citrus trees is shown by the fact that a series of wet years or a succession of dry years is usually followed by the prevalence of one or more diseases which had not been so troublesome immediately before, while following severe droughts or winters in which low temperatures occurred while the bark was growing, diseases of the bark and twigs often become alarmingly conspicuous. Such droughts or cold periods coming when bark-growth is in abeyance do not prove injurious even if severe, while their occurrence when the bark in certain parts of trees is still growing may be very disastrous.

Different diseases dominate at different times, and the same relative destructiveness of a particular trouble may recur after a time. Swingle and Webber, who were studying the diseases of citrus in Florida for the United States Department of Agriculture from 1892 to 1896, leave the impression in the report of their work[2] that the principal diseases ranked as follows in regard to their economic importance: blight, dieback, sour scab, sooty-mold, foot-rot, and melanose. Some years later withertip was shown by Rolfs,[3] to be a very destructive and wide-spread malady.

[2] Swingle, W. T., and Webber, H. J. The principal diseases of citrus fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul 8. 9 42. 1896.

[3] Rolfs, P. H. Withertip and other diseases of citrus trees and fruits caused by Colletotrichum gloeosporioides. U. S. Dept. Agr., Bu. Plant Ind. Bul. 52: 9 22. 1904.

The disease known as dieback has varied from time to time in its importance, although some of its phases are nearly always seen in abundance. In the nineties sour scab is said to have been confined chiefly to lemon (*Citrus medica* var. *Lemon*), lime (*C. medica* var. *acida*), and sour orange (*C. aurantium* var. *amara*), and only rarely to have occurred on grapefruit (*C. decumana* nearest to var. *Pomelo*). Melanose was then described as a new disease which was said to be spreading rapidly. At the present time the annual loss from sour scab on grapefruit is very large indeed, and that from melanose on orange is often heavy, owing to the greater susceptibility of melanosed oranges to decay. Sour scab, especially, seems to have increased in its destructiveness on grapefruit during the past three years. At the present time some of the bark diseases, like canker, gummosis, and foot-rot, are causing considerable alarm in some sections of the state, while sour scab is more generally dreaded owing to its wide distribution and great economic bearing on grapefruit growing. The so-called blight is only rarely heard of now, and when found often after more careful examination turns out to be foot-rot.

We have changed or "improved" wild plants by selection and culture so that they yield more and choicer economic products than they did in their wild state, but in so doing we have also modified the requirements of the plants. The natural conditions necessary for their normal development in the wild state are only partially understood, and the needs of the improved plants are even more baffling. Cultivated plants are therefore usually dependent upon intelligent culture for their required development and those most highly specialized need most consistent and continuous care. When the surroundings of such modified plants are allowed to revert or are not kept up consistently, marked injuries or diseases may follow. The plants which have sustained least artificial modification may be more hardy when grown in the proper climatic conditions simply because when given only intermittent attention the natural surroundings suffice for their full development. Trees carrying a heavy crop of fruit and having a very large leafage are much more seriously affected by sudden marked changes in the surroundings than are trees with only moderate leafage and small crops of fruit. A severe drought occurring at an unseasonable time has a more disastrous effect on heavily loaded trees than on those with a light load; drastic applications, or the omission of timely fertilization are also most harmful to the more refined or modified varieties of Citrus, or to trees bearing heavy crops. Unfortunately our knowledge regarding the requirements of citrus trees when pushed to high productiveness is too limited to insure continuous success. Sometimes the wrong guess is made at some critical turn, and consequently serious injuries and diseases result.

Broadly speaking, citrus diseases may be conveniently arranged in two classes, although one malady may have symptoms which appear in both categories. They can be grouped as diseases of the bark, and diseases of the leaves and fruits. That is, the troubles affecting the temporary and those affecting the more permanent parts. In some instances bark diseases, especially those of the roots, are not evident until after the normal functioning of the leaves has become deranged and show signs of trouble. The bark diseases in general are not well understood and no method has as yet been devised that always may be depended upon to prevent them; but trees affected by these maladies often can be helped by cultural and surgical means so as to aid them in overcoming such tendencies, and the healing processes can be encouraged. On the other hand, the diseases more typically affecting leaves, succulent twigs, and fruits are often preventable, even with our limited knowledge, if proper treatment is given early enough.

BARK DISEASES AND SUGGESTIONS FOR THEIR TREATMENT

Citrus trees are affected with a group of bark diseases which appear to have some things in common in that the growth periods of such affected trees are more or less out of agreement with the surroundings. Ordinarily the weather and soil conditions, including cultivation and fertilization, are such as to induce or permit both twig and bark growth only at certain seasons of the year, but under certain circumstances such growth is started or continued at times when because of the weather and soil conditions this normal completion is impossible. This group consists of such diseases as gummosis, foot-rot (crown-rot), dieback, canker, and withertip. These diseases begin with injuries which occur in the bark of certain rather definite parts of trees. The phase of canker affecting the bark differs, however, from the typical bark diseases because it attacks only the cortex while the others arise from troubles in the phloem and cambium.

Gummosis

The disease known as gummosis begins with the discoloration or disintegration of portions of the inner bark on the trunk or branches. Sometimes this is just above the roots and on the lower sides of large branches, but more frequently it occurs three decimeters or more above the roots or below branch crotches. It also represents the gumming stage of both foot-rot and scaly bark (fig. 1). The bark of the affected areas commonly has one or more cracks or clefts through which "sap" or gum exudes and in some cases the clefts occur where the inner bark is not injured enough to gum, as shown in figure 2. In the early stages "sap" oozes more or

less freely from affected areas during periods of sap flow. In the larger injured areas this "sap" often sours while in the smaller ones souring may not take place. In all cases gum eventually collects in the disintegrated inner bark and may exude through the clefts in the outer bark. In cases where much souring of the "sap" occurs the outer bark, over the entire area affected, usually dies and eventually a ridge of callus develops around the dead area. The affected portions soon appear sunken owing to the fact that the part of the tree covered with live bark grows in thickness while the bark of the dead areas dries and shrinks. Some phases of this disease have been given special attention in California.[4]

Apparently, gummosis and foot-rot merge into each other, both in their distribution on trees and in regard to the nature of the original injuries from which the two troubles develop. When the injured area of inner bark is large so that the outer bark also dies in a short time over the entire affected region, gumming is comparatively slight and gum only accumulates around the margin of the wound although considerable "sap" may run out at cracks in the affected area. However, if the injured places in the inner bark are comparatively small or are in very narrow strips, the outer bark over them may live for some time and the production of new wood around the margin of the injured inner bark, or on the wood surface just inside the disintegrating inner bark, lifts the outer bark away from the wood and thus forms pockets in which gum accumulates. Microscopic examination of the early stages in which gum is just beginning to form shows absolutely no difference between the gummosis and foot-rot types of injuries.

In instances where the inner bark had been less seriously affected or where the injured areas are numerous but very small and close together little or no souring of the "sap" occurs. The wood inside the disintegrated inner bark develops new, although rather imperfect bark which on further growth in thickness causes the old outer bark to crack and scale more or less; thus the imperfect new bark surface becomes exposed, here and there, through masses of gum and old scaly bark (fig. 1). This form of the disease often occurs high up on branches and is known as scaly bark.

The organisms so often found on and in the dead bark that is scaling off are only rarely obtained from affected areas in the early stages of this disease and for that reason one gets the impression that such organisms are of only secondary importance and can have no relation to the first cause of the injuries resulting in disease. The fact that practically all inoculation tests made with these organisms prove negative also supports the same idea.

[4] Smith, Ralph E., and Butler, O. Gum diseases of citrus trees in California. California Agr. Exp. Sta. Bul. 200: 235 270. 1908.

Foot-rot or crown-rot

When the inner bark of roots is injured the dying outer bark is kept moist by the soil and therefore may decay even before gumming has become very copious. We speak of this trouble as foot-rot or crown-rot. An advanced stage of it may be seen in figure 3, which shows that the death of roots must be followed by cutting away the corresponding portion of the top.

According to Curtiss[5] foot-rot of citrus was first noted in the Azores in 1832. It is said to have destroyed about a fourth of the trees there in ten years; but by 1873 the disease had disappeared from the Islands. In the meantime, however, it had been noted as occurring in the citrus growing portions of Europe. The disease was first noted in Florida during the late seventies.

Curtiss considered that foot-rot and gummosis are the same disease. His characterization of the trouble is good: "The prominent symptoms of foot-rot are exudation of a gummy or sappy fluid from near the base of the trunk, and decay of the bark in that region and of the roots below. The flow of gum and attendant decay extend upward and in a lateral direction, until it is girdled, also penetrating successive layers of wood. In some cases gum exudes from cracks in various parts of the trunk, or even on the branches, and in others the decay progresses without emission of gum. Attendant or premonitory symptoms are excessive and rather late blooming, the flowers being small and mostly unfruitful, and arrested or unnatural development of the foliage, which becomes yellow and drops. The disease manifests itself in the top, on the same side as the base, and makes like progress above and below." "It almost invariably originates at the base of the trunk, and soon destroys the main crown or lateral roots. About the first indication of the disease is a foamy or frothy substance exuding from a crack in the bark." "In cutting out this diseased part very often a small pocket of gummy substance will be found. The wood in the vicinity of the trouble looks yellow and diseased, and smells sour."

Swingle and Webber[6] also give some observations regarding the general characters of the disease, and some suggestions regarding treatments. Hume[7] quotes some statements from Coogler that are especially interesting. "When I first began growing citrus trees in this county (Hernando) in 1867, there was no such thing known as foot-rot, and if it then existed

[5] Curtiss, A. H. Foot-rot, sore-shin, or gum disease. Florida Agr. Exp. Sta. Bul. 2: 29-35. 1888.

[6] l. c., pp. 28-34.

[7] Hume, H. H. Foot-rot. Florida Agr. Exp. Sta. Bul. 53. 151-155. 1900.

FIG. 1. Orange tree having the scaly-bark stage of gummosis.

FIG. 2 Bark-cleft at crown of seedling orange tree, showing by its width the amount of growth since bark was burst.

it was wholly unnoticed. The year 1878 was a very wet one, for it rained almost continually during the entire year. When the sap began to flow in the citrus trees the following spring (1879) it was noticed that in many trees it exuded from the bark at or near the ground, but no one paid any attention to it. This was really the commencement of the foot-rot in this county, so far as we can ascertain."

Former studies by the writer[8] on a very similar bark disease occurring on deciduous fruit trees, also throw some light on the development of foot-rot on citrus. The environmental factors having a causal relation to the two diseases are apparently comparable and in some respects iden-

FIG. 3. Foot-rot on a seedling orange tree, in advanced stage, showing dead roots and the removal of corresponding portion of dead top.

tical. Sections of the earliest stages found are remarkably like some shown on plate 1 of my paper on a histological study of crown-rot.[9] The subsequent stages in the development of foot-rot differ somewhat from those of crown-rot, but mainly it seems because of the natural differences between citrus and apple trees. A histological study of the development

[8] Crown-rot, arsenical poisoning, and winter-injury. New York State Agr. Exp. Sta. Tech. Bul. 9: 367–411. 1909.

Crown-rot of fruit trees, field studies. New York State Agr. Exp. Sta., Tech. Bul. 23: 3–59. 1912.

[9] Crown-rot of fruit trees: histological studies. Amer. Journ. Bot. **3**: —. 1916.

of foot-rot from the material now on hand, will doubtless add much desirable information to our knowledge of this disease.

As stated above, the beginning of this disease seems to be identical with that of gummosis except that foot-rot more commonly starts in the upper angle of crown roots. Among clumps of seeding trees it often begins where the trunks press against each other, but sometimes begins on underground portions or even in the gutter-like depressions between two roots. In case of some trees in foot-rotted groves, the bark, in the lower angle that branches make with the main trunks and in the upper angles that roots make with the trunks, is cracked without the further development of injury as shown in figure 2. However, sections through such healed ruptures show that a cleft had also occurred at right angles to the visible one. A separation of the tissues in the inner phloem had resulted in a tangential rupture extending two to five centimeters on both sides of the radial cleft shown in the figure. The callus growth from both sides had been so prompt that a complete fusion resulted. The wound-tissue mass is easily seen in cross-section knitting the old and new bark together.

The occurrence of clefts in gumming bark and the presence of similar clefts in the corresponding parts of other trees, suggests the idea that perhaps the development of the clefts and the injuries in the inner bark that invariably precede the development of cases of foot-rot or gummosis go back to some common but unknown cause. Their early stages usually become noticeable from March to July.

Studies of forests have shown that after trees attain a certain age the closeness of the stand induces self-pruning by starving out the lower branches. At the same time, the lower part of the trunk grows less and less in thickness per season and one or two years' growth at its base often may be wholly omitted while much growth occurs in the upper parts of the trunk. In that way a trunk of a tree which in youth tapers very rapidly from bottom to top, is converted into one that tapers much less. It has been found by years of experience in the forests of Europe that when trees of such a close grown forest are thinned out the lower part of the trunks of the remaining trees immediately begin growing more rapidly in thickness. At the same time it was also observed that the bark of the upper roots and about the lower part of such tree-trunks was very likely to become affected and decay, from one to three years after the forest was thinned. In these instances it is evident that foot-rot or crown-rot is somehow related to changes brought on by thinning out the trees in connection with the resulting changes of trunk-growth, and it seems that either the amount or the *unseasonableness* of the growth thus induced on the upper roots and at the base of the trunks has a causal rela-

tion to the disease. Wester[10] described a case where the trouble was apparently caused by an unseasonable and severe drought.

Foot-rot and gummosis seem more prevalent in groves which are subject to considerable fluctuations in the water supply, and especially in places where in dry seasons a very marked shortage of water results. These bark diseases usually become most apparent during the first and second growing seasons following injurious droughts or after low temperatures that occurred while the bark was only partially dormant. This may be summed up by saying that these bark diseases apparently develop from injuries arising in the inner bark of certain characteristic regions of trees in which bark growth often occurs at times during which the environment may be abnormal and inimical to growing tissues. Grove management, then, should be such as to induce timely and steady growth of trees during the normal seasons of growth, as well as to encourage dormancy during the dry and winter periods. Trees must, of course, also have enough room or light-exposure to permit the functioning of sufficient leafage to elaborate enough food for the growth of the lower part of the trunk and the roots as well as for the growth of the top. If the food elaborated by the leaves during the best part of the growing seasons is all used as it courses downward in the bark of trees, so that practically none of it reaches the base of the trunk and roots until *after* the upper portions of the tree have become dormant, it is evident that the bark on the lower part of the trunk and roots may grow after the close of the regular vegetative periods and thus be subject to injury by the occurrence of unusually severe periods in the environment.

It is impossible at present to draw any definite conclusions as to the actual cause of foot-rot of either forest or fruit trees, but, as stated above, it appears that somehow the timeliness, manner and amount of growth of bark occurring at the base of trees in relation to the more critical or limiting environmental factors (drought, water-logged soil, low temperature), are connected with the development of the trouble. Here, as in gummosis, affected areas of the inner bark in the earliest stages of the disease seem to be free of pathogenic organisms of any kind. It is highly probable, therefore, that foot-rot is not primarily due to such organisms.[11]

Surgical treatment of foot-rot and gummosis

Considerable reliable information regarding the care of wounds in trees is available. This care should be applied to trees already diseased.

[10] Wester, P. J. The situation in the citrus district of Batangas. Philippine Agr. Review **6**: 125–130. 1913.

[11] Briosi, G. Intorno al mal di gomma degli agrumi (Fusisporium limoni Briosi). Atti R. Acad. Lincei (Roma) ser. 3. **2**: 485–496. 1878.

as long as the trees pay for the time and space given them. Bark which has become affected should be removed as early as possible by cutting it around the margin of the injured area with a sharp knife held so as to cut the bark at right angles to the surface. The affected bark should then be peeled and scraped off. Tree surgery of this kind enables the living bark along the cut edges to grow rapidly in the direction of the wound and, if the exposed area of dead wood is not too large, it is soon covered over with a shell of living wood. If, meanwhile, the exposed wood has been protected by paint no decay will have set in and the efficiency of the tree-trunk as a water conductor will not be seriously impaired. On the other hand if dead bark is left on, or dead wood is allowed to become weathered, the wood often dies to the center of the trunk and thus reduces the water carrying capacity of the tree to such an extent that roots on the affected side die and the tree becomes injuriously affected by droughts and so forth. In case the wounds are large it therefore pays to cover the exposed wood with some good paint a few weeks after treatment. However, if much wood having a white, living surface, is exposed by the removal of affected bark, it might be covered with grafting wax at once instead of later with paint. Wax permits the development of new bark in such places, while exposure or paint kills the tissues of the outer surface and thus prevents the formation of new bark. This applies to roots as well as to trunks. The soil removed from about the roots, in order to treat them for foot-rot, should be replaced shortly after the treatment, or at least before there may be danger of frost.

When severely affected trees are found before the vitality of the bark above and below the dead girdle has become much reduced, inarching a sour seedling stem set at their sides, has been found to prolong the life of such citrus trees. Bridging such dead bark-girdles on apple trees with two or more vigorous young shoots, by grafting them in the sound bark above and below the dead girdle, has also proved practical and may possibly prove so in some cases of citrus foot-rot.

Dieback

This bark disease is very widely distributed in Florida and may occur on any variety of citrus, but it is most noticeable on grapefruit. The worst feature of dieback consists in the dying back of young shoots from which most of the leaves had fallen after attaining practically full size. The small, original buds in such leaf-axils often die, and, during the next following period of growth, rosettes of substitute or adventitious buds arise as shown in figure 4, the development of which results in a very bushy growth from which dead shoots project as shown in figure 5.

FIG. 1. The multiple-bud phase of dieback on grapefruit shoots showing in addition some bark lesions above at right.

FIG. 5. Grapefruit tree affected by dieback, showing numerous dead branches which had hardened in bent positions.

During the time such shoots are yet growing in length they are often so limp that when the wood is eventually hardened in them they are fixed in more or less abnormal positions. Twigs produced on dieback trees when both air and soil are sufficiently moist usually maintain normal positions and harden more or less completely, although certain places in the bark may remain imperfect and develop gum which may exude through ruptures in the outer bark or be retained in cavities in and under the bark where it was formed. The bark of affected shoots becomes yellowish and more or less mottled with gummous areas and eventually such twigs die back from the tip to a point where enough normal bark tissues remain to permit the development of new buds that may continue the elongation interrupted by the dieback shoots. In some cases the edges of the ruptured bark turn back and the entire broken and protruding surface assumes a reddish-brown color.

The rind of fruit on dieback trees is also more or less blotched by the occurrence of gummous areas in it. In case of bearing orange trees, this is often the only phase of the disease to become evident. These patches are first of a yellowish color and subsequently become darker. The affected spots may eventually merge into each other and thus give rise to various sized patches which become more or less checked as the outer rind dries out. Although this phase of dieback when occurring alone does not affect the trees very seriously, it causes great losses during certain seasons owing to the fact that affected fruits often split (fig. 7, *a*) and drop so extensively that by picking time only a small fraction of the original crop, and that very inferior in keeping qualities, is found on the trees. In seasons in which decay is especially abundant in the groves one-half to three-fourths of such remaining dieback or "ammoniated" fruit may rot in transit to market.

The causes of the disease. The cause of dieback has not been fully established, but it is said to have some relation to the relative abundance of nitrogen in soils and perhaps also to the form in which the nitrogen occurs. Fowler[12] in his interesting account of this disease gave some notions regarding its cause that still prevail. He maintained that the use of improper fertilizer or the improper use of good fertilizer is the cause of the trouble. Heavy applications of barnyard manure or other rich natural manures, or penning domestic animals among the trees were thought to have a causal relation to the disease. His contention is, however, that improper grove treatment only furnishes the predisposing

[12] Fowler, J. H. On "The Dieback" in orange trees. Proc. Florida Fruit Growers Assoc. **1875**: 62 67. 1875.

factors and that a fungus is the cause of the disease. Webber[13] subsequently enlarged on some of these ideas. In some cases stable manure along with commercial fertilizers have been liberally applied to dieback trees by *inexperienced* growers and resulted in greatly improving their condition, rather than in making the disease worse, as would generally be expected. Dieback seems to occur most frequently in portions of groves needing drainage, although it also occurs on high sandy land where the nitrogen content is very low and where only meager quantities of fertilizer are applied.

Some of the results obtained by Floyd,[14] at the Florida Experiment Station, indicate that, in addition to the unbalanced condition of the soil water as a nutrient solution, some deleterious substances the tree takes up from the soil may be, at least partially, responsible for the production of imperfect bark and wood in shoots of dieback trees. A conclusion recently announced by Lipman,[15] from the University of California, maintains that dieback trees lack nitric nitrogen, because organisms occurring in the soil convert all nitrogen present to ammonia, which is either absorbed as such by the roots and causes injury, or escapes into the air as a gas. Some of the writer's experiments of the past two years confirm the opinion often heard among the growers that this disease may be "cured" by the application of copper sulphate to the soil about affected trees. This is a rather peculiar and interesting fact that will be discussed in a later paper.

Withertip

This also is essentially a bark disease, although the fungi considered to be a secondary cause of the trouble are found, too, in dead spots of both leaves and fruits[16] of Citrus as well as on nearly all parts of other dead plants. The most conspicuous characteristic of the disease consists in the withering of twigs and shoots. Most of the withering twigs shed

[13] Webber, H. J. Fertilization of the soil as affecting the orange in health and disease. U. S. Dept. Agr. Yearbook, **1894**: 193-202. 1895.

Swingle, W. T., and Webber, H. J. The principal diseases of citrus fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul. 8: 14-20. 1896.

[14] Florida Agr. Exp. Sta. Ann. Rept. **1909**: 63-69; **1912**: 102-124; **1913**: 30-53; **1914**: 30-45.

[15] Lipman, C. B. The poor nitrifying power of soils and possible cause of "dieback" (Exanthema in lemons). Science **39**: 728-730. 1914.

[16] Rolfs, P. H. Withertip and other diseases of citrus trees and fruits caused by Colletotrichum gloeosporioides. U. S. Dept. Agr., Bu. Plant. Ind. Bul. 52: 9-22. 1904.

Clausen, R. E. A new fungus concerned in withertip of varieties of Citrus medica. Phytopath. **2**: 217-234. 1912.

their foliage before they die, but some wither more suddenly and before the leaves drop. The latter phase of the trouble is often conspicuous in April and usually consists in the withering of the succulent young shoots of the growth of the spring, while the former phase of the disease is usually

FIG. 6. Budded orange tree that bore heavy crop in 1914. Bark slightly injured at base of large upper branches Nov. 20, 1914. Its tops died with withertip in summer of 1915.

most conspicuous in midsummer. Affected succulent shoots appear to wither from the tip backward, while in the case of the other type some of the bark, at a point from a few to many decimeters back of the tip, is found affected or even dead before the twig or branch in question shows any signs of withering.

If the second type of withering occurs in a grove it usually makes its appearance during the latter part of, or following severe droughts, or after the occurrence of untimely cold snaps like that of November, 1914. In some cases it develops only on trees which had borne a very large crop to maturity. Twigs bearing ripe fruit often wither and die, and following that, the attached fruit either drops or decays. Owing to the fact that this most important phase of the disease develops chiefly on trees subjected to severe conditions during a part of the season, it appears as though irregularities in the water and food supplies in conjunction with severe periods in the environment may be the principal predisposing factors. It was found that many slight interior bark injuries sustained by some nodal regions of branches, and by some crotches, from the cold snap occurring November, 1914, resulted in much of this type of withertip. Some such bark injured trees continued to appear normal until July and then died back, appearing like that shown in figure 6.

All branches, leaves of which no longer receive enough light to prepare or elaborate the food needed for their growth, eventually die. That is nature's way of pruning a tree and ridding it of useless members. A similar result follows where the water conducted through the wood of a branch is insufficient to supply the needs of all the twigs and fruit spurs attached to it. The twigs and spurs of such a branch, the water conducting system of which is most advantageously connected with that of the main branch, may survive a severe drought without injury, while the less favored ones, or those using an excessive amount of water, may be forced to drop their leaves and eventually wither. When a tree is properly fertilized and given good cultural treatment as well as kept fairly free of its *useless* branches and withered twigs, the leaf spots and anthracnose spot of the fruit so commonly present in groves affected by withertip will be of minor importance.

Canker

The name canker has recently been applied by Stevens[17] to a disease that has considerable similarity to certain phases of dieback, and some characteristics suggestive of scab. It seems to have been brought to Florida from Texas, where it has been present for several years. At present canker is apparently confined principally to the northwestern and

[17] Stevens, H. E. Citrus canker. Florida Agr. Exp. Sta. Bul. 122: 111-118. 1914.

Wolf, F. A., and Massey, A. B. Citrus canker. Alabama Agr. Exp. Sta. Cir. 27: 97-102. 1914.

Berger, E. W., Stevens, H. E., and Sterling, F. Citrus canker. II. Florida Agr. Exp. Sta. Bul. 124: 25-53. 1914.

southeastern portions of the state, and it is in the latter section that most notice has been taken of it.

This disease affects the leaves, fruits and twigs of grapefruit, navel oranges, ordinary sweet oranges, and some other varieties of Citrus. The first indications of the disease on very young, tender leaves are usually shiny white and slightly raised spots about one-sixteenth to one-fourth inch or more in diameter, on the upper sides of affected leaves. On the fruit the cankers sometimes bear a resemblance to "ammoniated spots" that had been raised above the general surface, but more generally they appear as porous, flat warts of brown color, from one-sixteenth to five-sixteenths inch in diameter. The warts may occur singly or may be

FIG. 7. *a*, Orange affected by dieback (ammoniated) and subsequently split by growth pressure. *b*, Navel orange, showing single and confluent cankers. Texas grove, crop of 1914.

merged into one, forming large cankerous areas (fig. 7, *b*). On the twigs, cankers often appear much like excrescences on dieback twigs except that gum usually is absent and the outgrowth is more corky and has less longitudinal extension. These warty outgrowths arise in the *outer* bark and have a brown color, fibrous corky texture, and measure from one-sixteenth to one-half inch in diameter (fig. 8). The cankers on the shoots develop in the cortex and seem never to affect the stele. In consequence the cankered outer bark is soon cut off from the normal tissues within by the development of a corky layer between them and the part outside, the dead bark is ruptured and eventually sloughs off as the affected shoot enlarges. On one-year-old branches the dead remains of the old cankers

are much weathered, and rather inconspicuous. The one-year-old portion of *b*, in figure 8, illustrates this point and shows the striking difference between the appearance of recent cankers on the current seasons growth (above) and the remains of old cankers as they still adhere to the one-year-old-branch (below).

FIG. 8. Navel orange shoots and branches affected by canker. *A*, *C*, *D* as it appears on newly hardened shoots *B*, with two cankers above on new growth, and sloughing off of old cankered cortex from older growth below.

Cankered fruit tastes as good as smooth fruit, but owing to the fact that severely affected fruits are either culls or are of little commercial value, the greatest loss from this trouble is sustained in bearing groves. In a small grove in southern Texas where canker had been present for at least two seasons, about 80 per cent of the fruits of navel oranges and

grapefruit were considerably cankered in 1914, while only a few small spots could be found on the fruits of satsuma oranges in the same grove. In this as well as in another Texas grove the new growth was repeatedly sprayed with bordeaux mixture during its development in spring and early summer of 1915, and the disease failed to reappear. Some nurserymen in Texas as well as some growers in Japan claim that the application of fungicidal sprays keeps the disease in check. Apparently only the young fruits, leaves, and twigs are susceptible to this disease.

After being strongly impressed with the seriousness of canker, the Florida Growers and Shippers League, in cooperation with the State Nursery Inspector and the growers on the East Coast, formulated a plan in the early summer of 1911 to eradicate the disease from the state. Affected nursery and bearing trees were cut back and the prunings were

FIG. 9. Young grapefruit grove treated for canker. Affected portions of trees were cut back and stubs were painted with bordeaux paste. The new growth emerging from the bare, bordeaux-encrusted branches, was often severely affected by canker.

burned (fig. 9). The stubs were treated with bordeaux paste or other fungicides. In many cases the new growth subsequently emerging from the treated stubs soon showed the presence of canker as had been the case in several known instances in Texas, Louisiana and Mississippi. Bent on complete eradication a new method was devised of utterly destroying all affected trees and this has been applied with great energy ever since, but without eradicating the trouble.

The new method consists in applying kerosene with an admixture of about 10 per cent of crude oil, to affected trees by means of an ordinary spraying machine, and igniting the spray. In this manner even large bearing grapefruit trees are so severely burned and scorched as to kill them root and branch. Although this is apparently a most efficient method of disposing of affected trees the destruction of property is so great that it should be used only until some more economical means has

been found of keeping the disease within tenable limits. The results obtained in the two affected groves in Texas referred to above give at least a suggestion that should have a thorough trial.

In both 1914 and 1915 the inspection squad policing the canker-section of the lower east coast of Florida, reported a rapid decline in the number of new cases from July to late fall. In 1915 this decline was more marked than in 1914. Corresponding increases were also found from spring to June of both years. When it is recalled that new cases develop only during periods of elongation growth the matter becomes simple. The more rapid decline this year can unfortunately not be attributed to the work of eradication in view of the fact that the groves in the danger zone are no longer adequately fertilized and cultivated, and therefore do not have the usual number of late summer growths.

The cause of canker has not been definitely established as yet, but some evidence is at hand indicating that it may be of bacterial origin.[16] Yet, only a few scattered trees in a bearing grove may be affected, while the rest of them show no signs of the disease, while new sprouts breaking through the bordeaux coating of treated stubs, frequently develop abundant canker. Whatever may ultimately prove to be the cause of this disease, the writer became convinced early in 1914 that it is not due to fungi often found present in cankers as had been maintained by Stevens, Wolf,[17] and others. His own tests with bacteria isolated from young cankers were inconclusive.

This disease appears to have been in Texas at least six years. Owing to the fact that it is also present in Japan, the assumption has been made that it was introduced from there. But the citrus industry is old in Japan, and since it had not attracted attention there, it would seem that canker is either new to Japan or else that it is not as destructive a disease as is commonly assumed. Whatever may be the facts in this case, the present status of the question does not permit a rational conclusion regarding the original source of the canker.

The economic relations of this disease are very much like that of sour scab. Its only very serious phase, economically, consists of its effects on the fruit. All severely affected fruits are culls, and may drop as soon as they are ripe. Owing to the superficial nature of the bark canker, affected trees grow and fruit so nearly normal that some having had the disease two or three years seem almost as vigorous as unaffected ones, and they bear practically as much fruit as normal trees.

PLYMOUTH, FLORIDA

[16] Hasse, Clara, H. Pseudomonas Citri, the cause of citrus canker. Journ Agr. Research 4: 97–100. 1915.

4 STIPPEN AND SPRAY INJURY

C. H. Crabill and H. E. Thomas

Most pathologists who have expressed an opinion regard apple fruit spot or stippen as a physiological disease involving sap pressure and transpiration. A few have suggested that it may be a form of spray injury. Others attribute it to pathogenic fungi such as *Alternaria* sp. and *Phoma Pomi* (*Cylindrosporium Pomi*).

The various names, stippenflecken, apple fruit spot, Baldwin fruit spot, Jonathan spot, brown spot, and bitter pit have apparently been used to designate the same trouble. At least the written descriptions agree closely. Whether or not they are all the same remains to be seen. With the written descriptions before us and in the present state of our knowledge, it does not seem too radical to assume that they are identical.

For a number of years the so-called fruit spot or stippen of apples has been under observation in Virginia on the varieties Jonathan, Baldwin, Wealthy, Arkansas (Blacktwig) and Grimes. The following descriptive features serve to distinguish it.

The disease appears at, or a short time previous to, ripening time. The spots vary in size from minute depressions in the skin to areas of about one square centimeter. The skin of the affected area is alive, unbroken, more or less strongly depressed and of a deeper color than that over the surrounding healthy tissue. On a red apple the color is deeper red; on a green apple it is deeper green. Beneath the skin is a spherical or lens-shaped mass of brown, dry, corky tissue seldom more than five millimeters in diameter. After ripening begins the cells of this corky tissue are packed with starch grains while in the surrounding healthy cells the starch has largely changed to sugar. The cells of the corky tissue are plainly dead and unaffected by any changes which go on in the healthy pulp. This accounts for the sunken condition of the spots. A large proportion of the spots are found on the blossom half of the fruit.

Fresh razor sections, stained microtome sections, and several hundred isolation tests on various media during three summers have failed to reveal fungi in the affected spots.

It has been suggested that stippen may result from poisoning of cells immediately under stomata or lenticels, particularly at the time when the stomata are splitting to form lenticels and before a protecting layer of cork is formed to close the opening. Following this suggestion the

writers attempted to produce typical fruit spot or stippen by application of spray materials at all periods of development of the apple. The results of these experiments are presented in table 1. The sprays used were arsenate of lead (paste), lime-sulphur solution, bordeaux mixture and copper sulphate.

TABLE 1

Baldwin apples treated with spray mixtures

Series	Number of apples at beginning	Number of apples at end	Spray material used	Dates of application	Typical stippen	External spray injury
1	50	29	Arsenate of lead, 9 6 grams per liter	May 29, June 8 and 17	0	
2	50	31	Lime-sulphur 2 50	May 29, June 8 and 17	1	russetting
3	25	20	Lime-sulphur 1½-50	June 8 and 17	1	
4	25	21	Lime sulphur 3-50	June 8 and 17	0	russetting
5	25	25	Arsenate of lead, 15 grams per liter	June 8 and 17	2	burning
6	25	16	Arsenate of lead, 6 grams per liter	June 8 and 17	1	burning
7	25	11	Lime-sulphur 1½ 50	June 17 and 21	0	
8	25	21	Lime-sulphur 2 50	June 17 and 21	0	
9	25	22	Arsenate of lead, 15 grams per liter	June 17 and 21	0	russetting
10	25	23	Arsenate of lead, 6 grams per liter	June 17 and 21	0	
11	25	19	Bordeaux 4-5-50	June 21 and 28, July 6, 14 and 22	2	
12	25	15	Cu SO_4 2-50	June 21 and 28, July 6, 14 and 22	0	badly burned
13	50	42	Arsenate of lead, 9 6 grams per liter	June 28, July 6, 14, 22 and 28	5	
14	50	45	Arsenate of lead, 9.6 grams per liter	July 14, 22 and 28	1	
15	50	50	Checks bagged	May 29	4	
16		100	Checks unbagged		4	

The final notes were taken on September 2. After the first treatment the apples in each series were enclosed in glassine bags and remained so the rest of the season, the bags being removed only to make the subse-

quent applications of spray solution. It will be noted that the apples in each series received at least two applications of the spray material while those in series 11 to 13 received five applications. The treatments were so planned as to conform rather closely to the usual spraying schedules practiced by Virginia orchardists. The average size of the apples on the several dates were as follows: May 29, one-half inch; June 8, three-fourths inch; June 17, one inch; June 28, one and one-half inches; July 14, two inches; July 28, two and one-half inches. On July 21, stomata had begun to split to form lenticels, especially on the stem end. This splitting continued rapidly and was most active about July 28.

An examination of the table shows that none of the sprays used produced typical fruit spots, although some of them were strong enough to injure the skin. An occasional spot was found in several of the series but no more than in the checks. In this connection it seems desirable to state that in 1914 the apples on the same trees used in these experiments were badly affected with fruit spot. This same observation has been made in numerous orchards in Frederick County. The summer of 1914 was marked by drouth and a heavy apple crop. Fruit spot was abundant and serious. The season of 1915 has been generally very wet, the apple crop is light and fruit spot is very scarce. From these observations one is forced to conclude that spray treatment has nothing to do with apple fruit spot or stippen.

In several instances apples struck by hailstones when about half grown have exhibited, on ripening, a spot almost identical in appearance with stippen. Except that it is often larger and occurs more often on the stem end of the apple than elsewhere, it is indistinguishable from stippen. Similar spots have been repeatedly found on apples which have hung in such a position as to be blown against stubs of fruit spurs or raised places on the bark of nearby branches. This injury has been reproduced with great fidelity on Baldwin apples by tapping them with a round-faced wooden mallet on July 14 when they were about two inches in diameter. When examined and sectioned on September 3 these spots were found to be very similar to stippen. The brown corky tissue under the skin was filled with starch grains while the healthy cells adjoining held only a small quantity of starch.

In another attempt to produce stippen by artificial means, stigmonose was reproduced so faithfully that Mr. M. B. Waite wrote that there was no doubt about the specimens falling into the general class of stigmonose, although the insect punctures were a little too evident. This was done by injecting apples on July 14 with lime-sulphur solution or with arsenate of lead by means of a hypodermic syringe. The stigmonose thus produced may be described as a slightly depressed, highly colored

area of skin plainly punctured at the center and underlaid by a mass of dry corky tissue similar to that exhibited by stippen.

In view of the results obtained by these tests it seems that stippen or stippen-like spots, i.e., depressed, highly colored areas of skin underlaid by a corky mass of dead, brown cells, may be produced in several ways, viz., by bruising, by insect puncture, by injected poisons, by insufficient water or by any other agent which may kill a few cells before the apple is full grown.

Our results also indicate that stippen is almost certainly not caused by spray materials as they are commonly applied.

BLACKSBURG, VIRGINIA

5 INTERNATIONAL PHYTOPATHOLOGY[1]

OTTO APPEL

"Phytopathological problems are no longer local problems, but world problems, and the sooner we recognize and adopt this point of view, the sooner we shall be able to successfully attack them."—C. L. Shear, in Phytopathology 3: 84. 1913.

To speak of international matters at a time like the present seems purposeless, both because of the fact that between many countries cooperative work will be well-nigh impossible for years to come, and because of the destruction, over a wide field, of the fundamental principle of science—the belief in objectiveness and love of truth.

On the other hand there are still many countries in which the inclination toward cooperative work has not diminished, and for the others also the time will pass in which it is difficult for them to work together. Therefore it seems to me appropriate to hold to the thought of further cooperation, and to contribute as much as possible to the promotion of this object.

The necessity for cooperative work among investigators of all countries is generally recognized, and all who have learned to look upon the various plant diseases from an extended viewpoint will with conviction subscribe to Shear's words quoted above.

Not quite so distinct as the necessity for this work is the course to be followed in order to attain the end desired with the least expenditure of time and labor. This is probably due mainly to the fact that each one desires to follow the line which is most familiar to him, and is prone to assume that in this way the most important phase of the question is to be met. One, therefore, desires the establishment of special laboratories; another thinks that far-reaching legislative measures will further the object; some lay stress upon statistical methods, while others again would prefer to see the matter treated in a purely scientific manner, and to leave its application in practice to others. Finally, there are those who regard as superfluous all scientific investigations having no direct bearing on the question under consideration.

There is besides, another difference in the understanding of phytopathology, which can probably be explained by reason of the particular train-

[1] Read at the special meeting of the American Phytopathological Society, Berkeley, Calif., August 3, 1915.

ing of the individual investigator. The mycologist is likely to place the greatest emphasis upon the study of fungi; the plant physiologist, in accordance with his special line of investigation, will consider chiefly questions of nutrition, since plant physiology regards of foremost importance the vegetative processes and metabolism. The morphologist and ecologist will treat many pathological questions from the viewpoint of his specialty. The breeder by reason of his experience will be likely to consider all questions from the standpoint of breeding resistant sorts. The phytopathologist finally, with a preliminary knowledge of agriculture, will pay special attention to the dependence upon economic conditions.

This brief survey shows the diversity of phytopathology, and it is well known that in all these directions numerous works have already appeared and that the scientists of all countries, wherever engaged in scientific work, are participating in it. These have drawn not only upon their own personal experiences, but have worked also under the most varied outside conditions, and thus our science already stands upon an international basis.

So long as phytopathology was still an unexplored field, each one, wherever located, could work according to his inclination and realize that he was rendering service, and even to this day such work can not be dispensed with. In connection with it, however, there has developed the necessity of taking up all phases of important questions and to bring them to a comprehensive solution. The individual can accomplish this only as he is given the opportunity to extend his investigations over a wider field, either independently or through the assistance of the specialists and coworkers in various countries.

Let us take an example of this sort; to me the Fusarium problem naturally suggests itself in this connection. It is not long ago that the fungi of the genus Fusarium were regarded as unimportant, and so it happens, for instance in von Tubeuf's Handbook, that only a few lines are devoted to this genus. From various sources attention was then called to the fact that under certain conditions these fungi are of great significance, and it was brought to mind that earlier there existed at least a suspicion of the pathogenicity of species in this genus. The main difficulty in the way of progress lay in the fact that taxonomy was absolutely insufficient and that therefore it was frequently impossible to prove what species the various authors had before them. In order to remove this primary evil I undertook the preparation of various monographs on diseases, but with the first one submitted, by Schikorra,[2] I realized that this was not

[2] Appel, O. Beitrage fur Kenntniss der Fusarien und der von ihnen hervorgerufenen Pflanzenkrankheiten. 1. Schikorra, G. Fusarium Krankheiten der Leguminosen. Arb k. Biolog. Anst. Land- und Forstw. 5, no. 4. 1906.

the proper way. With Wollenweber I then undertook the preparation of the foundation for a monograph on the genus Fusarium.[3] A further very necessary work is a comprehensive monograph. On account of my position I am not able to devote the necessary time to the consideration of this individual study, and I have left the further elaboration to Wollenweber, who, thanks to the assistance of the U. S. Department of Agriculture, with which he has been associated for several years, has carried on the required work both here and in Europe, so that in the near future a good monograph seems assured.[4]

This work, from the standpoint of the pathologist, is only preliminary, and, strictly speaking, does not belong in the realm of phytopathology. But it has been shown, on this as well as on other occasions, that for the purposes of pathology many systematic questions require a greater elaboration than is needed for purely taxonomic purposes. Above everything, taxonomy must be extended to take in biological viewpoints. For this reason the phytopathologist must also undertake to work out such questions. However, just as the writer of a monograph on phanerogams can not bring it to a successful conclusion without consulting the herbaria of Kew, Paris, Berlin, and other places, so the writer of a monograph on the larger groups of fungi is compelled to examine original material in herbaria and collections, or in other words, either to communicate with investigators of other countries, or better still, to avail himself of these means of assistance right on the spot. That means, of course, that the special investigator must undertake research journeys, which form an essential feature of the individual work, and which in ultimate purpose and range are intimately connected with this work.

For newly described or verified species a further means of assistance is the "Centralstelle fur Pilzkulturen" of the International Botanical Society, which is a branch of the Phytopathological Institute, Willie Commelin Scholten in Amsterdam under the direction of Dr. Johanna Westerdijk. The advancement of this Station is also doubtless in the interest of international phytopathology, as Shear has already indicated. It should therefore be the duty of every investigator to send to this institution cultures of the fungi investigated by him, since living material, of course, is always of more value than dead material. In addition to this,

[3] Appel, O. und Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium. Arb. k. Biolog. Anst. Land- und Forstw. **8**: 1–207. 1910.

[4] It may be of interest to state that Dr. Wollenweber, who, at the outbreak of the war, joined the German Army, has now been granted a furlough for the purpose of continuing his studies, and that every facility for this purpose has been placed at his disposal by the Imperial Biological Laboratory in Dahlem.

however, it would be of advantage to distribute authentic herbarium material to the larger herbaria.

To go back to our example, we find that there are two types of Fusarium diseases, vascular mycosis and local tissue destruction. Each apparently has a somewhat different distribution. How far this distribution is connected with climatic and soil conditions has not been sufficiently worked out, although the fact that vascular fusarioses are particularly frequent in the warmer parts of America, as well as the statement of Jones[5] that the Fusarium of the cabbage-wilt disease is not able to infect except at a soil temperature above 17°C., would point to climatic influence.

All experiments intended to explain outward influences in the appearance of fungous diseases are for practical purposes not conducted in any one locality, since frequently only through widely diversified conditions the really authoritative factors are disclosed. This is also true of breeding resistant sorts. So long as we do not know the factors that cause resistance,[6] proof as to whether a kind is generally resistant or only in certain localities, can be obtained only by the cultivation under the most varied conditions.

Another viewpoint of importance to the question of resistance has been brought out by the work of Barrus.[7] As is well known, Barrus has proved that the resistance of various kinds of beans against *Gloeosporium lindemuthianum* differs with various strains of fungus. It is, of course, possible to isolate various strains or to send for them for the purpose of experimentation, but here again it becomes an international matter as soon as the work attains universal significance.

In many other details certain problems can only be solved by investigations carried on in widely separated localities. Therefore I will note a few examples. The biology of *Phytophthora infestans* has been set forth in the classic work of DeBary,[8] but he did not succeed in solving the question of oospore formation. Others also, working on the problem in Europe, have not been successful. In America, on the other hand, this problem has recently been solved.[9] Whether this was due to the different

[5] Verbal statement of L. R. Jones.

[6] Appel, O. Disease resistance in plants. Science, **41**: 773–782. May, 1915.

[7] Barrus, M. F. Variation of varieties of beans in their susceptibility to anthracnose. Phytopath. **1**: 190-195. 1911.

[8] DeBary, A. Die gegenwärtig herrschende Kartoffelkrankheit, ihre Ursache und ihre Verhütung. Leipzig, 1861.

[9] Clinton, G. P. Oospores of potato blight, Phytophthora infestans. Bien. Rept. Connecticut Agr. Exp. Sta. **1909–1910**: 753–774. 1910. Jones, L. R. Investigations of the potato fungus, Phytophthora infestans. Vermont Agr. Exp. Sta. Bul. 168, and others.

methods of work here, or whether oospore formation more readily takes place in America, has not been fully determined.

The rust problem also shows progress due to the extension of experiments into other countries. Gassner[10] during his activities in Montevideo made it a point to study the conditions of teleutospore formation. The complete manner in which he was able to accomplish this would not have been possible in Europe, for only in the subtropics are the conditions favorable for a continuous sowing of grain throughout the entire year.

Proof of the importance of another kind of cooperation was shown recently in the Department of Agriculture by a conference called to consider the white pine blister rust. From the reports of the American delegates on the one hand, and those of Kølpin Ravn and the writer on the other, it was plainly shown that the problem in the United States and in Denmark and Germany presented entirely different aspects, a fact which to my knowledge has nowhere been brought out clearly in the literature on the subject.

Here it is plainly indicated how necessary it is to have discussions by the representatives of the various countries in order to interpret the problem from all sides. It goes without saying that this again will influence the handling of the problem in the various countries. This is especially the case when legal measures against certain diseases are introduced. On account of ignorance of the conditions prevailing in other countries a certain severity is likely to result, causing an unnecessary interference with trade. This applies in both directions. A disease may occur in one country and possess absolutely no significance, while for another country it may be of importance, or become so. In such cases one side alone can not determine what measures may be the right ones, and only a knowledge of all conditions can lead to a just regulation, applicable to both sides. Such knowledge is best gained by means of research journeys. While the travels referred to above serve particularly in the interest of individual problems, they are also of general importance. In each country there should be certain phytopathologists who are familiar with the conditions in other countries. Such knowledge, however, is not attained by a short visit to the country in question. It is necessary, in addition, to enter into close relation with as many colleagues in that country as possible, and by means of a free exchange of opinions and the inspection of numerous typical conditions, to gain as comprehensive knowledge as possible.

This viewpoint was the determining factor when the invitation to visit this country came to me in 1914, and to Kølpin Ravn in 1915, and I think

[10] Gassner, G. Die Teleutosporenbildung der Getreideplize und ihre Bedingungen. Zeitschr. f. Botanik, 7, no. 2. 1915.

I can assert for us both that the manner in which we have been received here fully answered the purpose intended.

In my opinion the most important phase of such visits is the formation of close personal relations, for only by means of such can it be expected that the insight into strange conditions may reach a degree commensurate with the purpose in view. When such close contact has once been established, it will also become easier to apply to countries other than their own the experiences of the several investigators in certain branches. There are still a number of problems which in one country may be considered as solved, while in another this is not the case.

Such, for example, is the smut problem. You know that we in Europe generally regard the question of smut control as solved.[11] Here and there smut may still occur, even more extended outbreaks are not impossible, but in general the statement may be said to apply there, that "Each one has as much smut as he deserves."[12] That is to say, that by the proper application of the methods of control a more extended occurrence of smut may be prevented. We have preventive measures against the smuts which infect seedlings as well as flowers, and in addition. apparatus has been constructed which makes it possible to apply these remedies even on a large scale. In America, on the other hand, the smut problem does not seem to have been solved, at least the occurrence of smut in many localities is so pronounced that I was forced to that conclusion. Climatic, and above all, cultural conditions, seem to play an important part in this connection.

The solution may be arrived at by studying the conditions in a country in which the smut problem has been solved and by applying the measures adopted there to the conditions in this country, or by instructing a phytopathologist especially familiar with these questions to undertake a study of the conditions here. In the first instance, a colleague visiting Europe may be assured that he would receive all the assistance possible. The other way is possibly more difficult on account of the hesitancy in designating a stranger to undertake the solution of a problem. It is, however, the most certain and the shortest way, because one who has worked for years in one branch has at his command not only the experience shown by established methods of procedure, but also those obtained in the course of his investigations. This enables him, more readily than any one else, to recognize the salient features in which the conditions of both countries

[11] Eriksson, J International phytopathologic collaboration. Phytopath. 5: 133–138. 1915.

[12] Appel, O. Bekampfung des Getreidebrandes. Flugschrift der Deutschen Landwirtschafts-Gesellschaft, no. 8, p. 6.

differ, and upon which must depend the modification of remedial measures. Finally, it is immaterial who promotes a cause, so long as it is promoted.[13]

I mentioned smut as an example, as it is a question to which I have given special attention. There are, of course, also cases of which the reverse may be said, and such instances may constantly recur.

International relations may also be materially advanced by regular or occasional conferences. Personally I prefer informal conferences. For large international conferences it is impossible to avoid making up a program long in advance of the meeting. The statements which are then made always bear a more or less official character, and frequently do not contain more than a conscientious study of the literature on the subject would disclose. It is, of course, true that there are associated with these more intimate discussions, which by many are regarded as the more important part of conferences or meetings. Such conferences, however, can not be called frequently on account of the great expense, and more intimate discussions may also be had in other ways.

Thus it was agreed, in connection with the meeting of International Botanists, which was to have taken place in London in May, 1915, that the phytopathologists present were to meet informally for the purpose of freely discussing important questions. This agreement extended to American, German, and Dutch phytopathologists; each one was to make further propaganda, and since it was expected that a number of coworkers from other countries would take part in the Congress of Botanists, it was hoped that many countries would have been represented. Similar opportunities often occur, they only need to be utilized. Also, when a phytopathologist visits other countries he should be asked to participate in discussions of all kinds. I have learned the value of this myself, since I had the opportunity to be present at discussions in the U. S. Department of Agriculture as well as at meetings of other kinds. On the other hand, for example, Whetzel took part in Dahlem in the discussion of the potato question,[14] and in recent years meetings have frequently taken place between German, Austro-Hungarian, and Dutch phytopathologists, which have been recognized as so advantageous that it was intended to extend them as much as possible, and to supplement them with general inspections.

However, I wish by no means to designate the formal international conferences as undesirable; they are doubtless of value, and are especially indispensable in bringing about international agreement, but aside from

[13] Appel, O. Die Organisation des Pflanzenschutzes in Deutschland. Arbeiten der Deutschen Landwirtschafts-Gesellschaft, 1914.

[14] Vorschlage zur Untersuchung von Kartoffelmustern hinsichtlich ihres Gesundheitszustandes und ihrer Bewertung als Pflanz- und Speise-Kartoffel. Jahresber. Ver. angewandte Botanik 10: 12. 1912.

this, it should be the aim to have phytopathologists meet as frequently as possible, for the closer they come into personal contact the more advantageous will it be for international work. I would like to add a few words in regard to the plan for many years recommended by Eriksson, namely, the establishment of international special institutions. Eriksson proposed the establishment of institutions devoted particularly to the investigation of diseases of grain, of diseases of potatoes, beets, and similar crops, also of the grape-vine and fruit-tree diseases, and to locate them in such a manner that on the one hand they would be situated in the largest producing centers of these various groups of plants, and on the other hand, to distribute them also among the principal countries of Europe. These institutions were to be erected and maintained at common expense, and a specially equipped investigator was to be at the head of each and by independent research to serve the purpose in view. In Europe there is now no prospect of the establishment of such institutions. It would seem to me that the end in view may also be reached by other means.

In the event of the appearance in any one country of diseases of a cultivated plant, it is the duty of that country to employ every available means to avoid widespread injury to its agriculture. The scientific investigation of the disease is doubtless to be included in these means. To begin with, an attempt will be made to have such cases investigated by existing institutions, and if the current means are insufficient for that purpose, special sums will doubtless be appropriated. This is already the case. For years special sums have been set aside for the use of the Imperial Biological Institute in Berlin-Dahlem for investigations in smut control and beet and potato diseases, making comprehensive work possible. If, however, the existing institutions on account of their location or equipment are not in position to carry such work to a successful completion, the country in question will in self-interest establish special institutions for temporary or permanent investigations, and either attach these to existing establishments, or place them upon an independent footing. The formation of commissions to bring about cooperation among various institutions is another method which has been frequently undertaken. As examples of this may be mentioned the Laboratory for the Investigation of Grape Vine Diseases in Metz, a branch of the Imperial Biological Institute in Berlin-Dahlem; the Institute for Potato Diseases at Greeley, Colorado, under the direction of the U. S. Department of Agriculture; the Austrian Commission for the Investigation of Potato Diseases (especially the leaf-roll disease); the Pennsylvania Chestnut Tree Blight Commission.

If several countries have the same interests, each one must devote itself to the problem, but in addition, cooperative work should also become

possible, especially when the much desired personal relations exist between fellow workers. This also has occurred at the present time. I refer, for instance, to the cooperative work between Germany and France in connection with phylloxera,[15] and to the cooperation between Germany, Austria-Hungary, and Holland in the question of potato diseases.

A further advancement of such cooperative work may be brought about also by the exchange between various countries of experienced investigators or assistants. It has already become possible for individual phytopathologists to work in other countries, in university institutes or in special institutions. It would not be a difficult matter to have these individual cases take the form of an exchange. The phytopathologists in question would then take the place of those to be exchanged, and when they returned with added experience they might be reinstated in their old positions. The entire cost to be defrayed would be confined to that of necessary travel, a sum which in the light of the benefit to be gained would be insignificant.

Another advantage to be derived would be the fact that the utilization of the foreign literature would be extended; this use is now frequently hampered because of insufficient knowledge of the language and insufficient insight into the conditions of other countries.

You see, gentlemen, that I place the greatest weight upon the development of personal relations. When these have once sufficiently advanced, then the other questions, such as that presented by Shear, the establishment of an international association and a general organ for reference, will develop of themselves. Furthermore, the indispensable international conference and international legislation will then display greater unity of purpose than has been the case heretofore.

BERLIN-DAHLEM, GERMANY

[15] Borner, Jahresb k. Biolog Anst. Land- und Forstw. 9:—. 1914.

6

IDENTITY OF PERIDERMIUM MONTANUM WITH PERIDERMIUM ACICOLUM

George Grant Hedgcock

The occurrence of *Peridermium montanum* Arthur and Kern on the lodgepole pine, *Pinus contorta* Loud. (*Pinus murrayana* Oreg. Com.) in Montana[1] and its probable relationship to a species of Coleosporium found on species of Aster in the same region has already been noted by the writer.

In July, 1914, specimens of *Peridermium montanum* on *Pinus contorta*, collected by Forest Assistant West in the Gallatin National Forest near Bozeman, Montana, were received by the writer from Acting Forest Supervisor A. H. Abbott. Inoculations were made by the writer on July 7, 1914, in the Pathological Greenhouses at Washington, D. C., on plants of the following species, control plants of each species being set aside to check the results: *Aster conspicuus* Lindl., *Coreopsis verticillata* L., *Elephantopus tomentosus* L., *Helianthus divaricatus* L., *Solidago canadensis* L., *S. multiradiata* Ait., and *Vernonia glauca* (L.) Britton.

On July 22, 1914, the uredinia of a species of Coleosporium appeared on the leaves of two plants of *Aster conspicuus*, and on August 23, 1914, the telia were found present. None of the remaining inoculated plants became infected, and all the control plants remained free from the rust. The species of Coleosporium obtained on *Aster conspicuus* closely resembles *Coleosporium solidaginis* (Schw.) Thüm. in its morphology and is now assigned by the writer to this species. This is proof that *Peridermium montanum* is the aecial stage of *Coleosporium solidaginis* as known in the Northwest. From this it follows that *Peridermium montanum* Arthur and Kern is identical with *Peridermium acicolum* Underwood and Earle which has hitherto been known as the aecial form of *Coleosporium solidaginis* in the eastern United States.

Arthur and Kern,[2] however, consider *Peridermium montanum* distinct from *Peridermium acicolum* and note differences in the length and in the

[1] Hedgcock, G. G. Notes on some western Uredineae which attack forest trees. Mycologia **4**: 144–145. 1912.

Notes on some western Uredineae which attack forest trees. II. Phytopath. **3**: 16–17. 1913.

[2] Arthur, J. C., and Kern, F. D. North American species of Peridermium on pine. Mycologia **6**: 117. 1914.

walls of the aeciospores, which may or may not finally hold as specific. Unless greater differences than have been found by the writer can be distinguished between the eastern and western forms of *Coleosporium solidaginis*, there are not sufficient reasons in his opinion for making a separate species of these western forms. The spore variations here are no greater than exist between the aeciospores of the western form of *Peridermium pyriforme* Peck (*Peridermium bethelii* Hedgc. and Long) on *Pinus contorta murrayana*, and those of the eastern form of this Peridermium on *Pinus divaricata* (Ait.) Du Mont de Cours, yet these forms are considered as one species.

Peridermium montanum, now recognized by the writer as the western form of *P. acicolum*, has been found in the United States as follows:

MONTANA

On *Pinus contorta* (*P. murrayana*)—Gallatin National Forest, Middle Creek, *Stuart*, F. P.[3] 2990; *George*, F. P. 11181; *H. E. West*, F. P. 15552; South Douglas Creek, *H. E. West*, F. P. 15553; Rimini, *F. D. Kelsey* (type of species, Herb. N. Y. Bot. Gard.).[4]

In the Dominion of Canada, *Peridermium montanum* has been found as follows:

ALBERTA

On *Pinus contorta* Loud. (*P. murrayana*)—Banff, E. W. D. *Holway* (Fungi Columb. 2541); Rocky Mountains, *Macoun* (Ellis Collection 573, Herb. N. Y. Bot. Gard.).

These data do not, however, greatly extend the previously known range of the aecial stage of the fungus. Arthur and Kern[2] previously reported its range as follows:

On *Pinus murrayana* Oreg. Com. Montana (Blankinship, Stuart); Washington (Suksdorf 302 & 645); Alberta (Holway); Rocky Mountains, Canada? (Macoun).
On *Pinus scopulorum* (Engelm.) Lemm.,[4] Montana (Kelsey).

Coleosporium solidaginis, the uredinial and telial stages of the fungus, has a wider known range than the aecial or Peridermium stage. The Western form of the Colesporium has been found in the following States:

[3] F. P. = Forest Pathology Investigations number.

[4] Dr. P. A. Rydberg and the writer have examined this collection and find that the host species is *Pinus contorta* (*P. murrayana*) and not *P. scopulorum* (Engelm.) Lemm. This renders doubtful the occurrence of the fungus on the latter species of pine, since no other occurrence has been reported.

CALIFORNIA

On *Aster chilensis* Nees (*A. chamissonis* A. Gray)—San Francisco, *M. A. Howe* (46, Fungi of California); Palo Alto, *C. F. Baker* (1713), Plants of the Pacific Slope).

On *Aster laevis geyeri* A. Gray—Mineral, *Long*, F. P. 17851.

On *Aster radulinus* A. Gray—Berkeley, *W. C. Blasdale* (Herb. N. Y. Bot. Gard.).

On *Solidago californica* Nutt.—San Francisco, *M. A. Howe* (46 Fungi of California).

On *Solidago confinis* A. Gray—Pasadena, *A. J. McClatchie* (Herb. N. Y. Bot. Gard.); San Bernardino Mts., *S. B. Parrish* (5311, Plants of Southern California).

COLORADO

On *Aster hesperius* A. Gray—Steamboat Springs, *Hedgcock*, F. P. 3883.

On *Aster laevis geyeri* A. Gray—Steamboat Springs, *Hedgcock*, F. P. 3885.

On *Aster lindleyanus* T. & G.—(Locality not given).[5]

On *Solidago oreophila* Rydb.—Tolland, *E. Bethel* (405, 2382); *Hedgcock*, F. P. 15886; Boulder, *Hedgcock*, F. P. 15864.

IDAHO

On *Aster adscendens* Lindl.—Trinity, *J. F. Macbride* (533, Plants of Idaho).

On *Aster conspicuus* Lindl.—Lake Pend Oreille, *L. F. Henderson* (4337, Ellis Collection, Herb. N. Y. Bot. Gard.); St. Maries, *Hedgdock & Weir*, F. P. 11107; Priest River, *Hedgcock & Weir*, F. P. 9494.

On *Aster salicifolius* Lam.—Caldwell, *E. Bartholomew* (802, 4011, Fungi Columb.).

On *Aster laevis geyeri* A. Gray—Castle Creek, *Hedgcock*, F. P. 9595; Priest River, *Hedgcock & Weir*, F. P. 9488; St. Maries, *Hedgcock*, F. P. 9524.

MONTANA

On *Aster conspicuus* Lindl.—Bozeman, *F. D. Kelsey* ($\frac{9}{5}\frac{2}{5}$, Herb. N. Y. Bot. Gard.); *E. T. & E. Bartholomew* (4112, Fungi Columb.); *Hedgcock*, F. P. 11173 and 11175); Monarch, *Hedgcock & Weir*, F. P. 11126; Red Lodge, *Hedgcock*, F. P. 11163; Thompson Falls, *Hedgcock & Weir*, F. P. 9446 and 9446a.

On *Aster eatoni* (A. Gray) Howell—Camp Geduhn, Lake MacDonald, *Hedgcock & Weir*, F. P. 11075; Locality not given.[5]

On *Aster foliaceus* Lindl.—Sand Coulee, *F. W. Anderson* (99, Parasitic Fungi of Montana).

On *Aster laevis geyeri* A. Gray—Summit, *Hedgcock*, F. P. 11109; Bozeman, *Hedgcock*, F. P. 11174.

[5] Arthur, J. C. Uredinales No. Amer. Flora 7, pt. 2: 91–92. 1907.

On *Solidago canadensis* L.—Silesia, *E. T. & E. Bartholomew* (4313, Fungi Columb.).
On *Solidago glaberrima* Martens—Locality not given.[5]
On *Solidago missouriensis* Nutt.—South Douglas Creek, *Hedgcock*, Helena, *F. D. Kelsey* ($\frac{8}{7}\frac{8}{8}$); Butte, *F. D. Kelsey* (Herb.) N. Y. Bot. Gard.

WASHINGTON

On *Aster eatoni* (A. Gray) Howell—Seattle, *C. V. Piper* (64, Wash. Flora).

The Coleosporium stage of this rust has also been found in the Dominion of Canada as follows:

BRITISH COLUMBIA

On *Aster occidentalis* Nutt.—Locality not given.[5]
On *Solidago multiradiata scopulorum* A. Gray—Locality not given.[5]

From the preceding data on known distribution[6] it will be seen that the present known range of the aecial stage of the fungus as represented by the Peridermium in the United States is confined to the State of Montana; and in the Dominion of Canada to Alberta, while the western range of the uredinial and telial forms of the fungus as represented by *Coleosporium solidaginis* is much more extensive, having been found in the States of California, Colorado, Idaho, Montana, and Washington in the United States; and in British Columbia and Alberta in the Dominion of Canada.

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[6] The writer has examined all the specimens cited except those credited to Arthur's Uredinales.

INOCULATION EXPERIMENTS WITH PERIDERMIUM MONTANUM

James R. Weir and Ernest E. Hubert

A form of leaf Peridermium, which has previously been reported from Montana as *Peridermium montanum* Arthur and Kern by Arthur and Kern (1906, 1914)[1] and by Hedgcock (1912, 1913)[2] was found by the writers, May 13, 1915, on the lodgepole pine, *Pinus contorta* Loud., near the Savenac Nursery of the U. S. Forest Service at Haugan, Montana. The aeciospores of this Peridermium taken from the needles of the lodgepole pine were sown upon *Solidago canadensis* L., *S. missouriensis* Nutt., *Aster laevis geyeri* Gray, *A. hesperius* Gray, *Arnica cordifolia* Hook., and *Castilleja miniata* Dougl. in the greenhouse at Missoula and at the field camp in Idaho, under control conditions, with the results shown in table 1.

On June 14, the following observations were made at the Savenac Nursery:

Case No. 1. A small seedling of lodgepole pine with its lower branches heavily infected with the needle Peridermium was found growing along the eastern border of the nursery beds. Surrounding this tree and just beneath the lower branches were several plants of *Solidago canadensis* L. The leaves of the Solidago were covered with the sori of *Coleosporium solidaginis* (Schw.) Thüm. The plants farther away bore but few sori and some bore none at all.

Case No. 2. Two larger trees about ten or twelve years old had a heavy infection of Peridermium on the needles of the lower branches. Just beneath these branches were plants of *Aster laevis geyeri* Gray and *Solidago canadensis* L., both having the Coleosporium in abundance on their leaves. The infection by the Coleosporium diminished on the Asters and Solidagos as the distance from the trees increased, the heaviest infections occurring on the plants situated immediately beneath the lower branches of the lodgepole pines. Castilleja plants in close proximity to the trees were normal and free from infection.

[1] Arthur, J. C., and Kern, F. D. North American species of Peridermium. Bul. Torrey Bot. Club **33**: 403–438. 1906. North American species of Peridermium on pine. Mycologia **6**: 109–138. 1914.

[2] Hedgcock, Geo. G. Notes on some western Uredineae which attack forest trees. Mycologia **4**: 140–147. 1912. Notes on some western Uredineae which attack forest trees. II. Phytopath. **3**: 15–17. 1913.

Cases Nos. 3, 4, and 5. Three isolated seedlings of lodgepole pine had their lower branches infected with the Peridermium. In all three cases *Solidago canadensis* L. and *S. missouriensis* Nutt. growing within a radius of two feet of the trees were heavily infected with the Coleosporium. Plants farther away were slightly infected and some not at all.

Case No. 6. An isolated seedling of lodgepole pine had most of the needles of the crown infected with the Peridermium. Just beneath the lower branches a group of *Castilleja miniata* was found growing in normal health. No trace of infection could be found on the leaves. Within a

TABLE 1

*Inoculation data for Peridermium montanum on needles of Pinus contorta**

NUMBER OF PLANTS INOCULATED	NUMBER OF PLANTS NOT INOCULATED, FOR CONTROL PURPOSES	HOST LOCALITY	SPECIES INOCULATED AND METHOD OF INOCULATION	DATE OF INOCULATION 1915	UREDINIA	TELIA	DEGREE OF INFECTION
2	1	Savenac Nursery, Haugan, Mont	*Arnica cordifolia* (dusted)	May 17	No result		0
1	1	Savenac Nursery, Haugan, Mont	*Arnica cordifolia* (wounded)	May 20	No result		0
1	1	Savenac Nursery, Haugan, Mont	*Castilleja miniata* (wounded)	June 3	No result		0
2	1	Savenac Nursery, Haugan, Mont	*Castilleja miniata* (wounded)	June 3	No result		0
2	1	Savenac Nursery, Haugan, Mont	*Solidago canadensis* (wounded)	June 16	1 plant July 19		Slight
1	1	Savenac Nursery, Haugan, Mont	*Aster laevis geyeri* (dusted)	June 16	No result		0
2	[illegible]	Savenac Nursery, Haugan, Mont	*Aster laevis geyeri* (dusted)	May 22	2 plants June 14		Medium
2	2	Savenac Nursery, Haugan, Mont	*Solidago missouriensis* (dusted)	May 22	2 plants June 14		Medium

* All plants covered by paper bags to isolate.

radius of one and a half feet several plants of *Aster laevis geyeri* Gray and *Solidago canadensis* L. had their leaves covered with eruptions of *Coleosporium solidaginis.* The infection on these plants diminished in direct proportion to the distance away from the lodgepole pine.

Field and greenhouse inoculation experiments performed upon three Aster and four Solidago plants with the aeciospores of *Peridermium montanum* from the lodgepole pine needles developed the characteristic and identical Coleosporium found upon similar plants cited above. The

inoculations made upon the three plants of *Castilleja miniata* showed negative results.

These experiments and observations prove the alternate hosts of this Peridermium to be species of Aster and Solidago, as far as aster is concerned confirming the suggestion of Hedgcock (1912). For the first time successful inoculations are here reported on species of Solidago. The rust produced is that heretofore known as *Coleosporium solidaginis* (Schw.) Thüm., developing as the alternate stage.

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8 A STUDY OF THE BROWN ROT FUNGUS IN NORTHERN VERMONT

H. E. BARTRAM

Persoon (1) in 1796 gave the name *Torula fructigena* to a fungus which he found on the decayed fruit of *Prunus domestica, Amygdalus persica* and Pyrus; but in 1801 he changed its name to *Monilia fructigena.* In 1851, Bonorden (2) described *Monilia cinerea* as the cause of small gray, sometimes brownish, conidial tufts on fruit. *Monilia cinerea* and *M. fructigena* have been widely confused but Saccardo in 1886 recognized both of them. Woronin (3) made a careful study of the two species and arrived at the conclusion that there could be no doubt that there were two species, one attacking principally stone-fruits and the other more prevalent on pomes. In 1901, Aderhold (4) confirmed Woronin's conclusion from work based on measurements of the asci and ascospores of both species.

The ascomycetous nature of these two species of Monilia was surmised by Schroter (5) in 1893, and he placed them in the genus Sclerotinia as *Sclerotinia fructigena* and *S. cinerea.* The peziza cups of the ascomycetous stage of one of these fungi were discovered in 1902 by Norton (6) who first noticed them on the ground of an old peach orchard in Maryland. To the fungus which he found on the mummied stone fruits Norton gave the name of *Sclerotinia fructigena*, and this is the title by which it is still commonly known in the United States.

The difficulty in differentiating between *Sclerotinia fructigena* and *S. cinerea* is accentuated by the fact that the species from the stone-fruit can be readily carried over to the apple or pear, and vice versa. The following are the more important points of divergence as worked out by Woronin (3), Aderhold (4) and others:

1. The conidia of *S. fructigena* always are larger than those of *S. cinerea.*
2. The conidial tufts of the former either are a clear brownish yellow or ochre and large, while those of the latter are ash-gray and small.
3. There is a difference in the shape of the conidia, those of the *S. fructigena* having an elongated ellipsoidal form, while those of the *S. cinerea* are more rounded, although they are somewhat lemon-shaped in both species.
4. *S. fructigena* occurs in nature on pome fruits while *S. cinerea* attacks stone-fruits such as plums, cherries and peaches.

5. Between the conidia of the former species are disjunctors, while in the case of the latter none are present, and the conidia separate by a tearing apart of the tissue of the walls.

6. The ascospores of *S. fructigena* are pointed sharply at the ends, while those of *S. cinerea* are rounded.

7. The ascospores and asci of the former always are larger than those of the latter.

During the last few years some valuable additions to our knowledge of these two fungi have been made by Ewert (7), Matheny (8), Conel (9), Reade (10), Pollock (11), and Jehle (12). Ewert's special contribution was his demonstration of the fact that *S. fructigena* and *S. cinerea* differ materially in their ability to pass successfully through the winter. The color of the conidial tufts on the fruit were used as a means of recognition, yellow for those of *S. fructigena* and gray for *S. cinerea*. In addition to the exposure of the conidia to outdoor winter temperatures, some were subjected to artificial cold as low as −20°C. (−4° F.). The exposed conidia were then used to infect susceptible host plants. The experiments were conducted for two winters at Proskau, Germany. That of 1909–1910 was very mild, but that of 1910–1911 was much colder and, during a cold period between February 7 and February 16 the thermometer registered from −7 to −21.7°C. Ewert's conclusions were that the spores of *S. cinerea* are able to live over winter in Proskau on sweet and sour cherry mummies as well as on those of plums and still be capable of producing infection in the spring, while the spores of *S. fructigena* usually lose their ability to germinate at the beginning of the winter whether occurring on pomes or on stone-fruits such as the plum.

Matheny (8) and Jehle (12) from comparative studies of material from Europe and this country have concluded that there are two species but that the common one in the United States is *S. cinerea*. The work of Matheny is very complete and is based on fruit inoculations, characters in pure culture and numerous measurements of asci, ascospores and conidia from various sources.

Reade (10) finds only one species common in New York, but the asci and ascospores produced by it are larger than those of *S. cinerea* and also than those the measurements of which were given by Norton. He considers it, therefore, to be *S. fructigena* as the dimensions agree fairly well with the size given by Aderhold (4) for that species.

Pollock (11), from measurements of conidia found at Ann Arbor, Michigan, and a few measurements of asci and ascospores from plums and peaches from two localities in Michigan, finds only one species but this with smaller asci, ascospores and conidia than those of *S. fructigena*, although not as small as those given by European investigators for *S. cinerea*.

Conel (9) found the average size of the conidia from all sources (mummied fruits and pure cultures) to be 13.3 by 7.6μ, which, while it is smaller than the average size given by Matheny, is nearer to those of *S. cinerea* than to those of *S. fructigena*. While his data on the vitality of the conidia over winter are not always consistent, he was able to show that in the latitude of Urbana, Illinois, conidia may survive the winter.

OBSERVATIONS IN VERMONT

The two winters chosen for these observations could not have been better in respect to contrast in temperature conditions. The winter of 1912–1913 was generally considered to be as mild as any that has occurred in recent years, while that of 1913–1914 was exceedingly severe. The periods of cold weather in the former winter were brief and not numerous and at no time did the official temperature at Burlington go below −24°C. During the latter season the cold was almost continuous with some long periods of below zero weather and at times a minimum temperature of −33°C. was reached. Thus an opportunity was presented of contrasting in one locality very divergent weather conditions.

Exposure of conidia to cold. Some plum trees in a garden at Winooski, Vermont, furnished an abundance of material for the work during the winter of 1912-1913. Tests of the conidia from these fruits made in hanging drop cultures in the laboratory in early November showed abundant germination.

Mummied fruits hang on their pedicels in spite of severe storms, but in order to insure some of them against falling off, a few choice clusters of dry, infected fruits were enclosed in coarse cheese cloth sacks tied to the branches. The cloth was thin enough to permit the free passage of air and moisture to the plums.

The winter of 1912–1913 was unusually mild, but on February 9, the temperature remained for 18 hours below −18°C. and at one time reached the minimum for the winter, −24°C. The conidia were brought into the laboratory from time to time and germination tests made. Results of these tests are shown in table 1.

Pure cultures of the fungus were made from the local plums, and these cultures, together with pure cultures secured from the New Jersey Agricultural Experiment Station were exposed during the winter in an open barn. So far as could be observed there were no differences in the germination of the conidia left on the plums hanging on the tree and those exposed to the cold in the form of pure cultures. Similar trials with pure cultures were made again during the winter of 1913–1914.

Inoculations of buds and flowers. Twigs of plum and cherry bearing both leaf and flower buds were brought into the laboratory on April 20

TABLE 1

Germination tests of conidia of Sclerotinia after subjection to cold for varying periods of time.

DATE OF TEST	MEDIA	GERMINATION	NOTES
Nov. 4, 1912..	Synthetic sugar broth	Nearly all germinated after 30 hours	No previous cold weather
Dec. 28, 1912 .	Prune broth and prune agar slants	Germination of conidia as yet unaffected	Previous minimum −9°C.
Feb. 4, 1913 .	Synthetic broth and synthetic agar slants	Many conidia do not germinate even after 48 hours, but plenty of growth on both media	Previous minimum −21°C. but much fairly warm weather
March 21, 1913	Synthetic broth	Good germination, but much fewer than on previous trials. Do not germinate as rapidly	Mild weather on the whole but one period with a minimum of −24°C.
April 17, 1913..	Synthetic broth	Many conidia will not germinate and others are slow in starting, but results are about as in previous test	Mild weather since the last test

and by April 25 were open enough to inoculate. Inoculations were made with a sterile needle both from the exposed pure cultures and mummied plums. The twigs were placed in water and a bellglass lined with moist filter paper was placed over the dish containing the twigs. Control buds were exposed to the same conditions. Infection was secured in six days on the plum and in four days on the cherry. The control buds kept healthy for nine days and then began to wither but without infection.

During the winter of 1913–1914, the material on these trees was so very scarce, owing probably to the very dry summer of 1913, that it was felt to be necessary to make inoculations on a few ripening plums. The inoculation was made from the pure cultures made the preceding year. Some of them were very successful and it was these artificially infected plums, enclosed in muslin sacks, that furnished the material for the second year's observations. The record for the observations made during this time is shown in table 2.

The last two tests made show that, while the extreme cold has had its effect in killing a large percentage of the spores, there were still an abun-

TABLE 2

Germination tests of conidia of Sclerotinia after subjection to cold for varying periods of time

DATE COLLECTED	MEDIUM USED	GERMINATION	NOTES
Dec. 18, 1913	Tap water	Abundant growth in 24 hours. Practically all the conidia germinated	Previous minimum −12°C.
Jan. 1, 1914..	Synthetic sugar broth	Same as above	Previous minimum −30°C.
Jan. 30, 1914..	Synthetic sugar broth	Good germination but not as many show vitality as in previous test	Previous minimum −32°C.
Feb. 11, 1914	Tap water	Only fair germination. Many conidia plasmolyzed	No lower temperature and warmer weather has prevailed
Mar. 21, 1914	Synthetic broth	Scanty germination Only a few conidia vigorous, others plasmolyzed	Long period of cold weather in February
April 17, 1914 .	Tap water	Same as previous	Weather much warmer

dance of spores viable and apparently capable of producing infection. Unfortunately none of these conidia were used for purposes of infection of young flowers as had been done in the previous year, but there can be no doubt that it would have occurred as the germ tubes were long and apparently vigorous even in the germination in the tap-water.

The observations made during these two winters seem to warrant the following conclusions: (1) The Vermont brown-rot fungus conidia are resistant to a minimum temperature of at least −32°C. (2) Alternate freezing and thawing of the conidia tend to lessen their vitality but not entirely to destroy it. (3) Winter storms remove only a portion of the conidia from exposed mummied fruits.

In view of Ewert's work, the writer feels confident that our common native brown-rot fungus is *S. cinerea*. This belief is further strengthened by the measurements of the conidia obtained in this vicinity.

Measurements of conidia. Hundreds of conidia were measured in the attempt to get a representative average of the size of those derived from various sources. The measurements are given in micro-millimeters in table 3.

These conidia measurements are somewhat larger than those obtained either by Matheny or Conel, but do not approximate those given for *S. fructigena*. The measurements obtained for conidia from naturally infected plums agree exactly with those obtained by Reade (10) for the conidia of *S. fructigena*. The name in this case means nothing, however, as Reade found only one species present; and, as the name *S. fructigena* had the prior usage, he assumed it to be this form. Matheny found that the conidia obtained from mummied fruit from different parts of the country exhibit some variations in size. The larger size of the conidia obtained locally may have been such a sectional variation. In any case, there is not sufficient difference in size to justify the classification of our local fungus as anything other than *S. cinerea*.

TABLE 3

Average measurements of conidia of Sclerotinia

SOURCE OF CONIDIA	MINIMUM SIZE	MAXIMUM SIZE	AVERAGE SIZE
	μ	μ	μ
Plums	14 3 x 9	18 x 14 3	17 x 11
Synthetic agar	12 8 x 9	18 x 10 7	14 3 x 10
Prune agar	14 3 x 10 7	30 4 x 21 4	19 6 x 14
Plums, artificially inoculated	10 8 x 9	23 4 x 14 4	16 2 x 10 9

Color of conidial tufts. Ewert considers the yellow conidial tufts of *S. fructigena* and the gray ones of *S. cinerea* as one of the easily recognizable points of difference. The writer never has seen tufts of any color other than gray, either on diseased fruit or on pure cultures grown in the laboratory. Apples inoculated from pure cultures of the brown-rot fungus showed this color of the conidial tufts. In the inoculation tests made on buds and flowers, the fructifications were always ashy. The color of the tufts, therefore, would indicate further that our species is *S. cinerea*.

Disjunctors. Woronin (3) in his thorough investigations of these two species of Sclerotinia mentions the presence of disjunctors between the conidia of *S. fructigena* as a possible means of identification. No disjunctors were found on any of the local conidia examined. The conidia are fastened together in chains by their outer covering and separate by a tearing apart of this tissue. Woronin mentions this tearing apart of the connective tissue as a characteristic of *S. cinerea*.

Measurements of asci and ascospores. The peziza cups are rarely found in Vermont, only one lot ever having been seen here to the knowledge of the writer. A careful search during the past two years at the season when

they might have been expected, failed to reveal any, although mummied plums were observed in great abundance under the trees. The measurements made were taken from material obtained in the spring of 1909 at Madison, Wisconsin.

The ascospores were blunt at the ends as is characteristic for *S. cinerea*. The author's measurements are as follows: Average size of asci (120 measured) 150.4 by 8.8μ; average size of ascospores (180 measured) 10.1 by 7.1μ. These sizes agree with those obtained by Aderhold for the European form of *S. fructigena* but are larger than those he obtained for his *S. cinerea*. They also agree favorably with the measurements of Reade and Matheny (table 4) who worked on material found in this country. Just why the measurements do not agree more closely with those for *S. cinerea* is not certain; but all results show a wide variation in this one species.

TABLE 4

Measurements of asci and ascospores of Sclerotinia

AUTHOR	S. FRUCTIGENA		S. CINEREA	
	Asci	Ascospore	Asci	Ascospore
Aderhold	120–180 x 9–12	11–12.5 x 5.6–6.8	89.3–107.6 x 5.9–6.8	6.2–9.3 x 3.1–4.6
Reade	125–215 x 7–10	10–15 x 5–8		
Matheny	135–173 x 6.8–10.8 mostly 151 x 9.4	9.3–14.2 x 5–7.4 mostly 11.8 x 6.3		

CONCLUSIONS

Two general facts may be derived from the data presented above and their comparison with the results secured by European and other American investigators:

1. The common form of brown rot of stone fruits, as found in Vermont is due to the fungus known in Europe as *S. cinerea*. This is conclusively proved not only by the measurements of the conidia, the absence of disjunctors, the gray color of the conidial tufts, but more especially by the persistence of the vitality of the conidia through the winter.

2. The conidia, both those already present as well as those produced from the dormant mycelium in mummied plums, present a danger of early spring infections that has not been generally recognized. The spores from the apothecia are probably abundant in certain seasons, but in others they appear to be entirely absent and the conidia and dormant mycelium

serve to carry the brown-rot fungus over the winter. However, the fungus lives over the winter either in the form of conidia or of dormant mycelium which will yield conidial tufts during the first warm moist weather.

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NEW OR NOTEWORTHY FACTS CONCERNING APPLE RUST

N. J. Giddings and Anthony Berg

The apple rust fungus, *G. Juniperi-virginianae,* has been the subject of considerable study during the past few years. The writers have given much time and attention to investigations concerning its life history, and the control of the disease it causes. Some of the more important facts brought out in the work will be briefly mentioned.

There has been some difference of opinion as to how long a period of moisture was required to induce germination of teliospores. Good germination has been secured repeatedly after moistening a gall for from one to two hours, and abundant sporidial discharge has occurred within less than three hours after first applying water to a gall. Moreover, records of observations show that one such sporidial discharge, under normal field conditions, took place in from six to eight hours after rain first began to fall.

Forcible ejection of the sporidia has been observed and there is some evidence that an outer membrane or wall is ruptured at the base of the sporidium previous to the final act of discharge. Very few sporidia are discharged below a temperature of 50°F., even when the sori have been moistened for one to two hours in water at about 70°F.

Earlier field records showed a pronounced drop in humidity every time sporidia were discharged, but in 1915 there was a decrease in humidity of only 3 per cent. Laboratory experiments are being conducted to determine whether the sporida may be discharged in an absolutely saturated atmosphere.

On some occasions when there was an abundant sporidial discharge and the conditions as to moisture and temperature were favorable, it has been found that no infection took place even in nearby orchards. The failure of sporidia to produce infection in such cases was evidently due to insufficient air current. It would therefore seem that a wind of fairly high velocity would be required to disperse the sporidia in order to have a severe and widespread infection.

Contrary to this conception the infection which took place on May 12, 1915, was the most widespread yet observed by the writers, although the wind velocity was only one to two miles per hour. The temperature and humidity were remarkably constant during that infection period.

There was also considerable fog, a factor not previously considered, and this may have had an important part in distributing the sporidia over such a wide area.

Evidence has been secured showing that severe apple rust infections cause premature loss of foliage, decreased size of fruit, and very appreciable diminution in vigor of tree. It has also been found that the number of rust spots per leaf and the relative location of such infected leaves have a very definite relation to the number of leaves which fall during any certain period.

The destruction of cedar trees, *Juniperus virginiana,* for a radius of one-half mile around orchards has frequently been recommended as a means of control, but during the past season this disease was very destructive in orchards which had no cedars within one-half to three-fourths mile of them. The number and location of cedars would have important bearing on this point, but the writers do not believe that anything less than a mile radius should be considered, if good results are to be secured. The actual cost of cutting out red cedars as they occur in the eastern part of West Virginia does not appear to be very great. Figures for an area of over 1,100 acres showed an average cost of about forty-eight cents per acre.

Considerable attention is being devoted to a careful study of meteorological conditions as related to the different phases of apple rust infection. This is a many sided problem, but it is believed that a series of records extending over a period of several years will yield valuable results.

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THE CONTROL OF EXPERIMENTAL CONDITIONS IN PHYTOPATHOLOGICAL RESEARCH

ALDEN A. POTTER

Few pathologists fail to recognize the desirability of controlling the conditions under which their experiments are conducted. Many have endeavored to control them in part, with varying degrees of success. There exists, however, as it seems to the writer, a fundamental necessity for improvement in this regard which is not fully realized. The realization of this necessity is doubtless largely contingent upon the recognition of the feasibility of accomplishing a real control of experimental conditions in botanical research. Nevertheless a consideration of the fundamental facts upon which the need of such control is based should assist materially in this realization which seems so much to be desired.

PRINCIPLES

Among the more highly developed organisms in which man is sufficiently interested to have made a study of their pathology the physical conditions of environment exercise a much more direct and therefore more immediately important influence on the plant forms than on those of the animal kingdom. The normal, warm-blooded animal has a constant temperature determined by the very nature of its existence, while its food supply is variable and must be sought by various adaptations to the nature of the supply. With its motility, an animal, or more specifically man, is thus so constituted that the physical conditions of environment affect him only indirectly. Given a food supply, his physical condition is largely determined from within.

With autotrophic plants it is evidently quite otherwise. Their photosynthetic elaboration of a food supply, not their temperature or other physical condition, is the distinctively fundamental fact of their existence. Given a suitable physical environment, the plant is able through this inherent anabolic process to supply its own nutrition from the inorganic materials of soil and air. The metabolism of the plant is thus directly dependent upon external, physical conditions. As compared with that of an animal, therefore, the response of a plant to changes of this character is more immediate and more profound.

While it seems scarcely necessary to recall these fundamental distinc-

tions to anyone engaged in biological research, they are thus briefly summarized in order to point out the influence which they have had on the development of pathological science. This is in part at once evident. The science of medicine, even to the etymology of its name which it has outgrown, has developed about a system of therapeutics or curative measures, and these have been and still are in practice largely a matter of influencing conditions through the alimentary system: in simpler language, a matter of dosage or of diet. In phytopathology, on the other hand, therapeutics of any sort are of comparatively little avail.

The fact, however, that prophylactic measures and the general technique of research have been so highly developed in the study of animal pathology has led to a general acceptance of medical methods as a guide in the development of the newer field of phytopathology. There is much to be gained thereby, for certain basic principles, particularly in matters of sanitation and antisepsis, must be recognized as common to both. But it would seem necessary in connection with the recent rapid development of phytopathology to point out the dangers of drawing too close an analogy between the two. May we not otherwise fall heir to methods which really take no cognizance of things which are fundamental in the existence of a plant?

The cardinal requirements for the determination of pathogenicity as propounded by Koch with reference to the study of bacterial diseases, have only too recently been given prominence among workers with plants. In dealing with facultative saprophytes and parasites these rules of proof are manifestly a desideratum; yet where the parasitism is obligate they are at least of obscure application and in those cases in which the parasite itself is much more evident than any lesions or other signs of disease (e.g., rusts and smuts) they would even seem immaterial. Where parasites are not concerned they are, of course, essentially irrelevant.

The determination of pathogenicity by Koch's rules, however, *may* be of little significance even where lesions are produced. That a plant or portion of it should wilt or assume some abnormal coloration in the presence of some cryptogamic invader is of little significance unless the other conditions be stated; and if these be not normal to the host then a true pathogenicity, or at least its true nature, has not been determined. The test loses significance to the extent that conditions have varied from the normal. The fact that this is peculiarly true in phytopathology on account of the more direct and fundamental dependence of the plant upon physical conditions, as pointed out above, seems to have been largely overlooked in the adoption of medical methods of investigation in which dietary and other considerations have necessarily somewhat obscured the matter of physical environment. Important though the latter may

be to the animal, the essential point is that it is more immediately important to the plant and more fundamentally so.

But what of the cases of obligate parasites and of diseases of non-parasitic origin? Here are some of the most pressing and most difficult of our problems; difficult because in basing our technique on Koch's rules we are able only to collect negative evidence as to the pathogenicity of the more or less numerous saprophytic organisms present; or in endeavoring to study the physiological relations involved we are confused by the continual entrance of extraneous organisms.

If a sound technique is to be developed for this class of investigations we must again revert to a fundamental difference between plants and animals. It must be recalled that the infectious diseases of the latter are largely transmitted by infected food and by contact, while with the diseases of plants other agencies or carriers must usually enter into the cycle. The soil, and particularly the atmosphere,[1] are the foremost of these and for this reason the isolation of plants from any given infection is much more uncertain in the open field than is ordinarily the case with animals.

Our attempts to depend entirely upon medical standards of quarantine or isolation in investigations of pathogenic conditions have here led us into numerous difficulties. Many observers, by creating or observing variations in the environment of plants, as for instance in the use of fertilizers or of irrigation, have shown that certain conditions bring on abnormalities of a definite sort in the crop plant. They have then concluded that these conditions were the primary cause of the disturbance, forgetting that were the disease etiologically parasitic, the physiological phenomena in both the pathogene and the host, and in either case the reaction between the two, unquestionably would be influenced by the change in environmental conditions. As R. E. Smith[2] has recently pointed out, it is safer, with our present technique, to admit that a disease is etiologically unknown than to pronounce it a physiological[3] disease.

In brief, just as on the one hand a lack of control of physical conditions may lead to doubt as to the extent of the pathogenicity of an organism, so on the other hand the possible presence of an organism of any sort casts serious doubt on conclusions that a given disease is primarily due

[1] According to Chapin (Chapin, Charles The Sources and Modes of Infection. p. 313-314. New York, 1910.) the evidence of pathogenic infection of man through the atmosphere is practically negligible.

[2] Smith, Ralph E. The investigation of "physiological" plant diseases. Phytopath. **5**: 83-93. 1915.

[3] Melchers (Melchers, L. E. The grouping and terminology of plant diseases. Phytopath. **5**: 297-302. 1915.) has recently contended, and rightfully it would seem, that "physiological" is not a distinctive term to apply to any class of plant diseases.

to a physiological disturbance. It is thus of utmost importance to determine all the conditions of the plant's environment during an experiment.

PRESENT PRACTICE

In dealing with plants in the field these principles are at present applied in measuring physical conditions by the use of recording instruments. These are commonly in use by physiologists and ecologists. While the physiologist not infrequently neglects pathological factors and obtains fairly accurate approximations only by averaging large numbers, this does not justify the pathologist in neglecting the consideration of physical conditions. Indeed, he has double reason for considering them for he has to deal at once not alone with the physiology of a green plant, but also with that of the parasite. The physical conditions at the time of planting and during early development of cereals affected by smut, for instance, have an important bearing on the severity of the attack. Yet we have too little complete and accurate information in the matter and this can not be said to be an exceptional case. Data of this character should be sought by a study of field conditions.

In the field we are handicapped, however, by a serious difficulty, namely, the impossibility, in many cases, of controlling or measuring the biotic factors in the natural habitat. It is, in short, often impossible to run control or check plants in the field on account of the omnipresence of some parasite. We might cite, for instance, the cases of corn smut and the rusts of small grains. It sounds strange to have to confess that for this reason we have no definite criteria by which to estimate the effect of stem rust on the wheat plant. Indeed, American pathologists have been criticized by European reviewers for the statement that the reduction of the wheat crop in 1904 represented *in toto* a loss due to rust.[4] Field experiments and observations can never definitely answer such criticism.

A distinct case, however, presents itself in the greenhouse. Here the conditions are artificial, and unless carefully controlled are normal to comparatively few of our economic plants. Yet the control of physical conditions alone, which might be obtained in the greenhouse, is of superlative value to the experimenter.

The control of the atmosphere in the greenhouse laboratory assumes an added importance, however, if conditions which are sterile, or at least free from pathogenic organisms, could be obtained. Pure or at least known cultures have long been recognized as essential to a careful study of organisms in test tubes, yet the student of green plants seldom attempts

[4] Riehm, E. Getreidekrankheiten und Getreideschadlinge. Centbl. Bakt. [usw.] II, **34**: 452. 1912.

a culture of known composition or even a culture which he *knows* to be free from pathogenic organisms. The greenhouse is no more free from contamination than is the vicinity in which it is located—in many cases even less so. In flasks and similar apparatus[5] the experimental isolation of green plants has been attempted on a small scale, but the serious limitations of such methods need not be enlarged upon. If sterility of environment is indeed obtained, the other conditions become so distinctly abnormal that most plants do not long survive the seedling stage. Many physiologists have excused the dearth of studies under conditions of pure culture by the fact that sterility of environment is not normal to green plants. While it may be wondered why it is assumed to be any more normal to other organisms, the pathologist, at least, can not seek refuge in this generalization, for his is the task of analyzing conditions which are *not* normal.

IMPROVEMENTS

Field conditions do not appear to offer great opportunity for radical improvement in available technique. In the greenhouse, however, the zoologists and entomologists are setting an example to which attention should be directed. Having come to at least a partial realization of the needs of experimental work connected with the growth of plants, they have spent and are spending liberally in efforts to control the physical conditions of their experiments. That their efforts, along with those of many botanical workers, seem in many cases to have been of little avail, may be attributed to the fact that their instrumentation has been largely of their own devising and has lacked the efficiency of construction which only a trained and experienced engineer could give it.

At the Kansas State Agricultural College, however, these attempts were abandoned recently in favor of a carefully developed system which has been installed under the supervision of the Division of Engineering by the Departments of Zoology and Entomology. Many such systems[6] have been designed in recent years for conditioning the air in a great variety

[5] These methods are summarized by Viktor Grafe in his Ernährungsphysiologisches Praktikum der höheren Pflanzen, p. 313 325, fig. 84–91. Berlin, 1914.

[6] For details of the principles of physics and engineering involved see:

Carrier, Willis H. Rational psychrometric formulae, their relation to the problems of meteorology and of air conditioning. Jour. Amer. Soc. Mech. Engin. **33**: 1309–1350, 14 fig. 1911.

Carrier, Willis H., and Busey, Frank L. Air-conditioning apparatus, principles governing its application and operation. Jour. Amer. Soc. Mech. Engin. **33**: 1611–1688, 43 fig. 1911.

Lyle, J. I. Atmospheric dehumidifying. Trans. Amer. Soc. Refrig. Engin. **8** (1912): 127–154, 16 fig. 1913.

of structures and they are now in operation in various industries such as silk mills, pottery works, lithographing establishments, and so forth, not to mention the ventilation of public buildings. Forced ventilation with washed air is the main advantage which these systems offer.

The greenhouse chamber installed at Manhattan, Kansas, has been in operation for a year, and has been described by Dean and Nabours.[7] A glance at the charts of temperature and humidity given in connection with this description will convince even the most skeptical that, within limits, the control of physical conditions in a greenhouse can be accomplished. The writer has seen the apparatus in operation and has been assured by those who have operated it that with proper attention it is capable of producing such results consistently.

Successful control should reasonably be expected to follow the careful application of correct principles. A forced change of air every minute (more or less according to the needs of the case in hand) necessarily provides a more adequate and responsive means of control than obtains in the commercial type of greenhouse. When the entering air is properly conditioned, the control approaches perfection. This, in principle, is most satisfactorily accomplished by thermostatic control of the temperature of the water spray through which the air passes (thus determining the dew point) and subsequent re-heating, also under thermostatic control, to a given point of saturation deficiency. Some manufacturers guarantee to furnish apparatus which will control a given set of atmospheric conditions within a range of 2°F. and 2 per cent relative humidity.

In the control of physical conditions, then, the only difficulty offered, aside from the control of light, is that of stating the conditions to be met in a greenhouse. In order to furnish specifications as to the capacity of the machinery to be installed we have to know (1) the minimum dew point required; (2) the maximum number of thermal units to be absorbed in a given time, which includes the refrigeration required to absorb the water transpired by the plants; (3) the maximum number of thermal units to be supplied in a given time. These data are dependent chiefly upon the experimental conditions of temperature and humidity which it is proposed to maintain as related to the climatic conditions under which it is proposed to operate the laboratory. Within reasonable limits of control the solution of such problems as arise is purely a matter of the capacity of the machinery to be provided and thus, of expense.

[7] Dean, George A., and Nabours, R. K. A new air-conditioning apparatus. Jour. Econ. Ent. 8: 107–111. 1915. The writer took up the question of similar equipment with the company which installed the Kansas plant, in the fall of 1912. He wishes to disclaim credit, however, for being the Mr. A. A. Potter to whom acknowledgments are made in this article.

Light conditions, however, since artificial light is of little or no avail for the photosynthetic activities of the plant, are the most difficult to control. For this reason, and also because humidity would be more easily controlled in a dry climate especially during warm weather (thus saving expensive refrigeration), the most suitable location for such a greenhouse laboratory would appear to be in a climate of little rainfall. In such a location maximum light conditions would be available most of the time and their reduction to any desired degree of intensity would be a comparatively simple matter.

But the control of physical conditions is not alone of importance. If sterility can be maintained the installation of an air-washer would be justified even if temperature and humidity were controlled no better than is now done. The incorporation of air-washers in ventilation systems, however, appears never to have been attempted as yet with this object in view. Specific data on which to base a prognosis of success in this direction are therefore largely lacking. Claims are made by some manufacturers that "absolutely clean air" is delivered by their washers. However, in recent tests of five washers in public buildings in Boston, Whipple and Whipple[8] have found that only about two-thirds of the suspended particles in the air were removed. In a recent letter to the writer,[9] the junior author, Prof. Melville C. Whipple of Harvard, gives it as his opinion that "these installations could be made to operate more efficiently if they were used for experimental work." He notes also that sterility is more easily obtained than absolute purity, i.e., freedom from all dust. It would seem that modifications of the present types of air-washers, designed to obtain the sterility of the air (possibly by the simple addition of active germicides to the water) could attain this end beyond a reasonable doubt.

That we should acquire at once, however, an apparatus precisely fitted to the needs of every problem presented is scarcely to be expected. Experimental apparatus must often be modified to fulfill the needs of the case in hand, as every research worker well knows; but that machinery has already been devised which in principle does answer the needs of the day in phytopathological research can no longer be doubted.

The expense involved is considerable; this can not be gainsaid. The Kansas installation, complete, has cost perhaps $2,000 and its operation requires $2\frac{1}{2}$ H.P. and enough oil, labor, repairs and other expenses to make up a daily operating cost of fully $3.[10] But even presuming that this first,

[8] Whipple, George C., and Whipple, Melville C. Air washing as a means of obtaining clean air in buildings. Heat. and Vent. Mag. **10**, no. 9: 13-19. 1913.

[9] Letter of November 19, 1915.

[10] Exclusive of power and heat the costs are about $1.00 per day. The writer is indebted to Dr. Nabours for the figures given.

small, experimental installation could not be improved upon as to costs, the matter of expense does not appear to be of material significance as compared with the ends to be gained.

For the control of physical conditions, the pathologist needs such a greenhouse equipment twice where the physiologist needs it but once; but even more does he need it for the conducting of pure culture experiments on the host. Can one call to mind such controversies as those on carnation spot, mosaic disease, crown gall, citrus canker, or the mycoplasm theory of Eriksson with his apparatus[11] for attempting the solution of the problems involved (and they are problems still much in dispute), without wondering what might not have been saved, or may not still be saved by a realization of the inadequacies of the technique employed in attacking these problems? Methods are needed by which Koch's rules may be applied with more facility and greater accuracy to those problems involving pathogenes of a more or less saprophytic character; but more especially must these methods also open up the way to a solution of the much more difficult problems of obligate parasites and non-parasitic diseases. In developing this technique we must recognize more fully that what Vice-President Zeleny has said in his recent address before the Section of Physics of the American Association for the Advancement of Science, namely that real progress in science is dependent upon the development of instruments, is as true in the field of botanical research as in any other line of investigation.

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[11] Eriksson, Jakob. Sur l'origine et la propagation de la rouille des céréales par la semence. B.-Essais de cultures isolées. Ann. Sci. Nat. Bot. VIII, **15**: 1-50, pl. 1-2. 1902.

PHYTOPATHOLOGICAL NOTES

The Phytophthora rot of apples. About the first of July, 1915, the senior author observed a peculiar brown rot lesion on several half-grown Oldenburg apples in his garden. The affected fruits were on the lower branches near the ground. Diseased fruits were found from time to time on the tree until the fruit began to ripen. The lesions resembled very much those produced by *Bacillus amylovorus*. No insect punctures were evident through which a pathogene might have been introduced. When placed in a moist chamber, the entire fruits became involved within two days. Isolations gave pure cultures of a Phytophthora which promptly produced conidia on potato agar. Cultures of the fungus were sent to the junior author who made careful comparison, on various media, with other Phytophthoras which he had growing. It is evident that the fungus is *P. cactorum* (Lib. et Cohn) Schroet.

Two series of inoculations of eight to ten apples each with the mycelium from pure cultures into healthy Oldenburg apples on the trees gave typical infections in every case. The junior author made similar inoculations from pure cultures of the organism into Rhode Island Greening apples at Presque Isle, Maine, and obtained like results.

Osterwalder[1] reports a rot of apples and pears which he found prevalent during early July of rainy seasons in Switzerland and which he attributes to *P. omnivora* de Bary (= *P. cactorum*). He found both conidia and oospores of the pathogene on rotted fruit on the ground. He also observed infected apples on low-hanging branches. He later reported this pathogene attacking nursery apple "buds"[2] during the first season of growth, girdling them. Bubák[3] records an outbreak of this disease in Bohemia on pears in 1910.

During October and November, this same pathogene was again twice isolated from apples purchased in the Ithaca market, once from a Tompkins King and on another occasion from Twenty Ounce. These isolations were made by Mr. Fernow, a student working on apple fruit rots, under the direction of Professor Hesler.

The writers have made no extensive study of the disease and report it only because this appears to be the first recorded appearance of the

[1] Centrlb. Bakt. 2: **15**: 435–440. 1905.

[2] Landw. Jahrb. d. Schweiz **26**: 310. 1912.

[3] Zeitschr. Pflanzenkr. **20**: 257–261. 1910.

pathogene on orchard fruits in this country. While Osterwalder regards it as destructive in wet seasons in certain varieties of apples and pears, the disease, as we have observed it, seems to promise little of danger to the fruit industry in this country.

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J. ROSENBAUM

Violet root rot of alfalfa in Virginia. In a survey of diseases of alfalfa in Virginia during the season of 1915, the presence of the violet root rot fungus, *Rhizoctonia crocorum* (Pers.) D.C. (*R. medicaginis* D.C., *R. violacea* Tul.), is noteworthy. It was found in a single field at Daleville, Botetourt County. A previous record of this disease from the same field, on material sent to them in 1914, was made by Reed and Crabill.[1] The fungus appears to be confined to the single field in this locality at present and is not known to be in any other locality in Virginia. This field is about eight acres in size and the alfalfa of five years' standing. The death of tops due to the fungus was first observed by the owner in 1914 and was said to be noticeable only on the last cutting, late in October, in both 1914 and 1915. An examination of the field showed the presence of the fungus, chiefly in the lower portions, marked by bare areas roughly circular in outline and six feet or less in diameter. Roots of dead and dying plants within these areas presented the typical appearance of the Rhizoctonia attack; the complete envelopment of the roots in a mat of violet-colored mycelium with numerous small "infection cushions" and hyphal strands, and the slipping of the bark from the root in pulling. The determination of the fungus as *R. crocorum* has been verified by Dr. B. M. Duggar and Dr. G. L. Peltier.

This record materially extends the known distribution of *Rhizoctonia crocorum* in the United States, being the first from the Atlantic States, so far as I am aware. Duggar[2] records reports of this fungus on alfalfa from Nebraska and Kansas and on potato from Oregon. The appearance of the fungus in isolated sections is suggestive of a more general distribution and of its probable introduction with imported seed.

F. D. FROMME

[1] Reed, H. S., and Crabill, C. H. Notes on plant diseases in Virginia observed in 1913 and 1914. Virginia Agr. Exp. Sta. Tech. Bul. 2: 37. 1915. Published also in Virginia Agr. Exp. Sta. Ann. Rept. 1913–14: 37. 1915.

[2] Duggar, B. M. Rhizoctonia crocorum (Pers.) D. C. and R. solani Kuhn (Corticium vagum B. & C.) with notes on other species. Ann. Mo. Bot. Gard. **2**: 403–458. 1915.

Note on the white spot of alfalfa. Stewart, French, and Wilson[1] have described a white spot disease of alfalfa leaves. A similar trouble has been observed in Virginia for a number of seasons. Although the losses from it are not serious, farmers frequently inquire about it.

The disease may be described as rectangular, whitish-translucent spots on the leaves, chiefly on the distal portions. The spots are thin and the cells of the affected area are flaccid. The epidermis of both the upper and lower surfaces is unruptured. Affected plants are usually unthrifty

FIG. 1. A typical case of white spot. Almost every leaf on the affected plant is spotted while the surrounding plants are entirely healthy.

and make a poor growth. It is probable that most of them soon die. This disease has been observed only prior to the first cutting.

Microscopic examination of whole spots and of razor sections of fresh material has revealed no parasite. Stained sections of imbedded material likewise give no clew to the cause of white spot. Thrust and dilution cultures on starch, protein, and sugar media have indicated an absence of parasitic fungi.

[1] Stewart, F. C., French, G. T., and Wilson, J. K. Alfalfa troubles in New York. New York State Agr. Exp. Sta. Bul. 305. 1908.

Affected plants show the spot on nearly every leaf, while adjacent plants are entirely free from the disease (fig. 1). This observation led to an examination of the root systems. The root below the crown was always found normal except for superficial injuries which were caused by chewing insects and which were common on all plants in the vicinity.

The upper surface of the crown, however, was always found in a state of decay. Sometimes this decay extended a short distance down into the pith of the taproot and up into the pith of the stems (fig. 2). The pith had turned brown and the cells separated very easily. From this tissue,

FIG. 2. The crown of the alfalfa plant shown in figure 1

Fusarium sp. and *Acrostalagmus* sp. were isolated by thrust cultures[2] on starch agar.

The fact that the crowns of plants showing white spot were always injured, while those of unaffected plants were not, pointed to the conclusion that the crown injury was directly responsible for the spots. Why this should be true lacks explanation but it is evident that the transpiration stream is interfered with.

Some healthy alfalfa plants were wounded by cutting away a portion of the tissue of the crown from above. On all of these plants typical white spots developed on the younger leaves in twelve days.

[2] Made by thrusting small pieces of tissue into solidified agar in petri dishes.

The fact that white spot appears only in early spring indicates that the injury which produces the disease occurs in late fall or winter and that after a period of feeble growth in spring the plant either recovers by repairing the injury or dies outright. C. H. CRABILL

Horse-chestnut anthracnose. During the season of 1914 the petioles and the midribs and veins of the leaflets of *Aesculus hippocastanum* Linn., in Washington, D. C., were commonly affected with anthracnose. A species of Colletotrichum was found fruiting abundantly on the lesions. The spores measured 4 to 4.9 by 14 to 21μ; on specimens taken in autumn the spines were very conspicuous, dark, several septate, 7 to 9 by 93 to 140μ. At first peripheral tissues only were affected. The fungus often produced acervuli on the lesions before conduction was cut off. In most cases the fungus ultimately penetrated to a sufficient depth to cause the killing of all tissues beyond the point attacked. Infection of the petiole at the point of juncture with the leaflets frequently occurred. Simultaneous wilting and drooping of all the leaflets, or of two or three of them, as a result of such petiole infection, was a rather common phenomenon. Lesions on the leaf blades were very closely limited to the veins, distinguishing the trouble from the leaf blotch and from non-parasitic leaf injury found on the same trees.

Living leaves of *Aesculus hippocastanum* with the typical petiole anthracnose were received from New Rochelle, New York. One of these lesions contained the fruits of an ascomycete, paraphysate, with 8-spored asci. The ascospores were oblong-ellipsoid, 1 to 2-seriate, 4.7 to 6.1 by 14 to 16μ. There is reason to suspect that both the ascomycete and the Colletotrichum found are identical, and should be referred to *Glomerella cingulata.*

ROY G. PIERCE
CARL HARTLEY

Personals. Mr. C. H. Crabill, formerly assistant plant pathologist of the Virginia Agricultural Experiment Station, resigned this position on September 15 to engage in farming. His present address is Cliffside Farms, Ethelfelts, Virginia.

Dr. F. M. Rolfs, formerly associate botanist and plant pathologist of the South Carolina Experiment Station, has accepted the position of horticulturist of the Oklahoma Agricultural College and Experiment Station, effective January 1. He is succeeded by Mr. Roy C. Faulwetter, formerly assistant in Botany at Columbia University.

Mr. J. G. Grossenbacher, pathologist in charge of citrus disease investi-

gations, Office of Fruit Disease Investigations, Bureau of Plant Industry, has resigned this position and has been succeeded by Prof. H. R. Fulton, formerly plant pathologist of the North Carolina Experiment Station. The latter vacancy has been filled by the appointment of Dr. F. A. Wolf, who previously held a similar position at the Alabama Experiment Station.

ABSTRACTS OF PAPERS PRESENTED AT THE SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, COLUMBUS, OHIO, DECEMBER 28-31, 1915.

Pathological quarantines in 1915. R. KENT BEATTIE

Under the authority of the Plant Quarantine Act of August 20, 1912, the Secretary of Agriculture has established foreign quarantines aimed at injurious plant diseases which in their present status exclude from the United States:

(1) All five-needle pines from Europe and Asia (because of the white pine blister rust); (2) potatoes from Newfoundland, St. Pierre, Miquelon, Great Britain, Germany, and Austro-Hungary (because of the potato wart) which quarantine is extended (because of the powdery scab) to include also Canada and all of continental Europe except Denmark and most of the Netherlands; (3) sugar cane from all countries (because of several serious diseases); (4) Citrus from all foreign countries (because of Citrus canker and other serious diseases); (5) corn from Java and India (because of *Sclerospora maydis*).

In addition to the above, Foreign Quarantines, established primarily to exclude certain insects, assist in guarding against the entrance of foreign plant diseases. Such quarantines exclude:

(1) Seven different kinds of fruit from Mexico; (2) cotton seed and hulls from all foreign countries (except Lower California); (3) avocado seed from Mexico and Central America; (4) two- and three-needle pines from Europe.

Domestic quarantines almost prevent the movement of cotton seed, hulls, and lint and of thirty-five different kinds of fruit from Hawaii to the mainland.

The potato powdery scab quarantine. R. KENT BEATTIE

The principal Domestic Quarantine aimed at the restriction of a plant disease which has been established under the Plant Quarantine Act is that regulating the movement of potatoes from the regions in Maine and New York infected with powdery scab.

The quarantine was designed to restrict the movement of this apparently dangerous introduction from Europe till its seriousness under our conditions and its relation to American agriculture could be determined.

The disease was discovered in Maine in the 1913 crop, the movement of which was regulated by the Maine authorities. Federal quarantine became effective in Maine August 1, 1914 and in New York, November 16, 1914.

The entire crop of the infected area was inspected and 27,600 cars were permitted to enter interstate traffic. As many as 132 inspectors were at work at one time. Potatoes were shipped to thirty-four different states. Not over sixty bushels of these went to the northern tier of states west of New England.

A careful survey of the potato-growing states which used Maine seed showed that the disease had established itself in but one place, a slight infection in northeastern Florida. Experiments reported by the Bureau of Plant Industry confirmed the probability that this disease would not become serious outside of the northern colder regions.

A Federal survey located the disease at one point in Minnesota and the state authorities reported four other infections. Three infections were reported from Oregon and one from Washington State by the state authorities. Federal quarantine being thus unnecessary for the southern states and having no effect on the northern ones, the quarantine was removed on September 1, 1915.

The phytopathological inspection service of the United States Department of Agriculture. G. R. LYMAN

The work of the pathological inspectors of the Federal Horticultural Board under the Plant Quarantine Act of 1912 falls into two categories:

I. Inspection of nursery stock privately imported from abroad or moving into or out of the District of Columbia in ordinary interstate shipments. Only woody plants or their parts for propagation are subject to inspection.

II. Inspection of government importations. Here all plant material for propagation must be examined by pathological and entomological inspectors. This material is large in quantity, comes from every quarter of the globe and is unlimited in variety both as to host plants and as to fungous and insect pests found thereon. After examination this material may be (1) passed with or without preliminary treatment; (2) grown in close quarantine; or (3) destroyed. The specially constructed inspection house adjoining the quarantine greenhouse is equipped with every facility for examination and treatment of plants and may be disinfected at will. Precautions similar to those used in contagious wards of hospitals are employed in suspicious cases. After passing inspection most plants are propagated at Yarrow, Md., where they are examined and treated periodically and again minutely inspected before final distribution.

Some interesting finds in the phytopathological inspection service for 1915. G. R. LYMAN

The following finds are of sufficient general interest to merit mention.

Citrus canker was discovered on nineteen different lots of citrus bud wood from the Philippine Islands. Citrus canker was not known to occur in the Islands and this discovery led to an investigation which showed canker to be well established there. Wither tip was detected on twelve lots of citrus bud wood from the Philippines and also on one shipment each from Japan, Peru, Australia and the Fiji Islands.

Powdery scab was detected on fifteen lots of potatoes from three localities in Peru. The presence of this disease on native varieties of potatoes grown near the upper limits of potato culture on the eastern slope of the Andes where potatoes are never imported seems to show that the disease is indigenous there. Powdery scab was also found on potatoes from Ireland.

The detection of the "Dutch Bulb Disease" due to *Botrytis parasitica* on two shipments of tulip bulbs to the Department of Agriculture from the United States Bulb Garden at Bellingham, Washington, revealed the presence of this disease in that garden. The same disease was found on tulips from Ireland and on narcissus from Holland.

Observations on the occurrence of Puccinia glumarum in the United States. H. B. HUMPHREY AND A. G. JOHNSON

Puccinia glumarum Erik. and Henn. was observed in the United States for the first time by F. Kølpin Ravn of the Royal Agricultural College of Copenhagen while inspecting a wheat field near Casa Grande, Arizona, in May, 1915. This species of Puccinia was first recognized and described by Eriksson and Henning in 1890,

prior to which time it had been confused with *P. dispersa*, *P. graminis*, and *P. coronata*. Thus far, in the United States, it has been observed on *Triticum vulgare*, *T. compactum*, *T. durum*, *T. polonicum*, *T. spelta*, *Secale cereale*, *Hordeum vulgare*, *H. murinum*, *Elymus canadensis* and *Bromus marginatus*. Geographically it seems thus far to be confined in this country to the Pacific Coast and intermountain states. Nothing is known of the source of its introduction into the United States, nor as to the length of time it has existed in the western states. The symptoms manifested by plants attacked by *P. glumarum*, though somewhat variable, are in the main not unlike those shown by those infested with *P. triticina* or *P. graminis* in the uredo stage. In the former, however, the smaller and roundish, bright yellow uredo-sori occur in definite lines or series, while in *P. triticina and P. graminis* the sori appear with less definiteness of arrangement. Because of the characteristic type of lesion produced by *P. glumarum*, Parker has proposed the adoption of the name stripe rust in order the more clearly to define this species from *Puccinia triticina* with which it is often confused. The teleuto-sori develop in long black lines on the leaves, culms, and glumes of the host. Our observations record but three varieties of wheat in which glume infection produced either uredo- or teleutospores. The severest epidemic of this rust was observed on the U. S. Experiment Farm at Moro, Oregon, where grain is grown without irrigation and where the average annual rainfall is approximately 11 inches and the average annual evaporation is approximately 45 inches.

Certain varieties (Dale's Gloria and Early Baart) showed an estimated infection of 70 to 90 per cent. Yet it has been shown, contrary to results observed in Sweden and elsewhere in Europe, that the varieties grown at Moro showing severest infection gave the highest yields Notes on varietal susceptibility were taken at Moro, Oregon, and Moscow, Idaho, the two points where the epidemics seemed most severe.

Preliminary notes on an heretofore unreported leaf disease of rice. G. H. GODFREY

Early in the fall of 1914, the writer observed in the rice-fields of Louisiana and Texas, in great abundance, a peculiar leaf-affection of rice plants. At a casual glance it resembled ordinary black rust of cereals, in fact, many of the growers spoke of it as rust. At that time, and since then at several different times, searches were made for pustules or other forms of fruiting bodies, and attempts were made to get the organism to produce spores, but thus far without result. Sections through the leaf showed a spot to be apparently a solid stromatic mass extending down into and replacing the host tissue. Attempts to culture the organism in agar plates and in sterile tubes containing moist cotton plugs resulted constantly in the development of numerous small black sclerotia-like bodies. They seem to develop directly upon mycelia growing out of the stromatic mass in the leaf. Preliminary inoculations with fresh cultures of these sclerotia-like bodies have produced definite lesions, the leaf becoming interlaced with strands of mycelium which have begun to mat together to form a definite stroma in the upper layers of the leaf. Artificial inoculations, however, have not yet produced the appearance of general infection which occurs on the leaf in nature. While the writer thinks it has been demonstrated that the organism he has obtained in culture is the causal organism, it still remains to identify that organism definitely, and to determine the conditions under which universal infection of the leaf takes place and the other usual details of pathological significance.

Further results in controlling certain barley diseases by seed treatments. A. G. JOHNSON

Using seed known to be infested with stripe disease (*Helminthosporium gramineum*), loose and covered smuts (*Ustilago nuda* and *U. hordei*), a series of seed treatments was run at Madison, Wisconsin, during the past season. These included copper sulphate (concentration and time of exposure were varied), copper sulphate and salt (concentration and time varied), bordeaux mixture (time varied), formaldehyde (strength of solution, time, and temperature varied), mercuric chloride (time and temperature varied), and three standard hot-water treatments. The series covered 57 plats, including 3 controls. Each plat consisted of six rod-rows.

Practically all of the treatments greatly reduced, and a number eliminated perfectly, the loose smut as well as the covered smut, while controls uniformly showed considerable infection from both. The stripe disease was reduced by a considerable number of the treatments, but was eliminated perfectly by only three as follows: (a) 40 per cent formaldehyde, 1 part to 240 parts water at 20°C., seed soaked 3 hours; (b) 40 per cent formaldehyde 1 part to 160 parts water at 10°C., seed soaked 2 hours; (c) 40 per cent formaldehyde 1 part to 160 parts water at 25°C., seed soaked 1 hour. In all three of these, germination was unimpaired and both smuts, as well as stripe disease, were eliminated perfectly. Controls averaged 11.7 per cent stripe disease, 1.1 per cent loose smut, and 1.8 per cent covered smut. Aside from formaldehyde, the copper sulphate and salt mixture gave best results, eliminating both smuts perfectly and leaving only two stripe disease plants in the entire plot.

A bacterial disease of barley. L. R. JONES, A. G. JOHNSON AND C. S. REDDY

The disease in question has been under observation during the past four seasons. It was first observed at Madison, Wisconsin, on two-rowed barley and later also on the square six-rowed varieties. The disease has also been noted on a wide range of barley varieties in the following states: Minnesota, North and South Dakota, Montana, Colorado, and Oregon.

The disease manifests itself chiefly on the leaves. As to form and size the lesions vary from irregular spots of various sizes to rather narrow stripes which may extend practically the entire length of the leaf. The lesions show a characteristic translucency, both when fresh and later when dried. They are at first water-soaked and later dry to a light brown color. A bacterial exudate is usually present on the lesions. Under humid conditions this may appear as numerous tiny droplets of cream-like color and consistency and is teeming with bacteria. With excessive moisture this may spread as a film over the surface. Under drying conditions this exudate quickly hardens into yellow granular beads or glistening scales easily detached and readily softened or dissolved again in water.

Isolation and inoculation work has shown the disease to be due to a single yellow organism. Numerous isolations have been made, characteristic lesions obtained, and the organism reisolated. The organism is short, rod-shaped, and actively motile with a single polar flagellum. Thus it is referable to Migula's genus Pseudomonas or Cohn's Bacterium as emended by Smith. The species is apparently undescribed. Work on the disease is being continued.

A bacterial disease of western wheat-grass. Occurrence of a new type of bacterial disease in America. P. J. O'GARA

An unusual type of bacterial disease has been found occurring on western wheatgrass, *Agropyron Smithii*. Rydb., in Utah Valley and Salt Lake Valley, Utah. Affected plants are usually somewhat dwarfed, but the most striking characteristic

of the disease is the presence of enormous masses of surface bacteria which produce a primuline yellow ooze or slime, forming layers between the stem and the upper sheath and between the glumes of the inflorescence. The floral organs are also extensively occupied by the organism. Knee-shaped bendings are often produced in the stem just above the upper node and these often protrude through the sheath. This usually occurs when the space between the upper internode and its surrounding sheath is entirely occupied by a deep layer of bacterial slime. The organism does not penetrate into the tissues until some time after it has covered the surface of the plant. It is then found in the sub-stomatic chambers and in the intercellular spaces. It has not been found occupying the cells.

The infected inflorescence rarely ever produces normal, germinable seeds. Thousands of infected spikelets have been examined and in no case have fertile seeds been found.

The organism has been studied in culture for several months and is found to be more or less closely related to *Aplanobacter Rathayi*, E. F. S., which causes a very similar disease of orchard grass, *Dactylis glomerata*, L. The organism, being nonmotile, belongs to the genus Aplanobacter. The writer proposes to describe the organism causing the bacterial disease of western wheat-grass as a new species of Aplanobacter.

Pathological morphology of wheat affected by stinking smut. MORTIER F. BARRUS

Published in full in this issue of Phytopathology.

Culture work on the heteroecious rusts of Colorado. ELLSWORTH BETHEL

Results are recorded from field and garden cultures of a number of heteroecious rusts. The work has extended over a period of five years, during which it was usually possible to duplicate the trials more than once in a season and to repeat them from year to year. The final conclusions are based upon the uniform success obtained by these repetitions. Extended and persistent observations in the field, pursued for a long period of time, have been the basis of the work.

Puccinia Stipae Arth. has been grown upon nine different Cichoriaceous and Carduaceous genera, *P. Andropogonis* Schw. upon eight species of hosts belonging to two genera, and *P. Agropyri* E. & E. upon four host genera.

The telial stages are reported for *Aecidium roestelioides* E. & E., *A. Allenii* Clint., *A. Phaceliae* Peck, *A. Onosmodii* Arth., and *A. Liatridis* (Webb.) Ellis & And.

Interesting or new aecial hosts have also been found for *Uromyces Junci* (Desm.) Tul., *Pucciniastrum pustulatum* (Pers.) Diet., *Puccinia amphigena* Diet., and some other species.

A new Cronartium on Orthocarpus is described.

Biologic forms of Puccinia graminis on wild grasses and cereals. A preliminary report. E. C. STAKMAN AND F. J. PIEMEISEL

Biologic forms of *Puccinia graminis* Pers., have been found to infect cereals and grasses as indicated in the following summary.

P. graminis tritici Erikss. and Henn.: wheat, barley, *Hordeum jubatum*, *H. spartinum*, *Elymus canadensis*, *E. virginicus*, *E. robustus*, *Agropyron occidentale*, *Bromus tectorum*, *Hystrix patula*. Rye can be attacked weakly. *Agropyron caninum*, *A. tenerum* and *A. cristatum* have been infected in the greenhouse, and the rust has been found on the first two in the field, but it is not yet known whether it occurs on them commonly.

P. graminis secalis Erikss. and Henn.: rye, barley, *Hordeum jubatum*, *H. spartinum*, *Elymus canadensis*, *E. virginicus*, *E. robustus*, *Agropyron repens*, *A. tenerum*, *A. occidentale*, *A. caninum*, *A. cristatum*, *A. imbricatum*, *Bromus tectorum* and *Hystrix patula*.

P. graminis avenae Erikss. and Henn.: oats, *Avena fatua*, *A. elatior*, *Anthoxanthum odoratum*, *Holcus lanatus*, *Phalaris canariensis*, *Koeleria cristata*, *Dactylis glomerata* and *Bromus tectorum* This form has also quite consistently weakly infected the following: barley, *Elymus canadensis*, *Lolium italicum*, *L. perenne* and *Festuca elatior*.

Barley and some of the grasses serve equally well as host for more than one biologic form, thus probably explaining the apparent capriciousness of the rust on certain wild grasses. The classification differs slightly from that made for cereals by Eriksson in Europe and Freeman and Johnson in this country. *P. graminis hordei* F. and J. is not used, and barley is added as a congenial host for *P. graminis tritici* Erikss. and Henn.

There was sometimes a difference in the virulence of the same biologic form when isolated from different hosts, but it was never sufficient to warrant considering the rusts distinct biologic forms. This was particularly true since the virulence of the same biologic form on the same host varied with weather conditions and the condition of the host plant.

Numerous and repeated attempts have been made to change the parasitism or increase the host range of the various biologic forms by means of so-called bridging hosts. Contrary to the earlier experience of some investigators, up to the present time all attempts made by the writers have been unsuccessful Neither has it been possible to rapidly increase the virulence of a rust strain on an uncongenial host by confining it to that host for a considerable period of time. The biologic forms, when isolated in pure form, have so far remained sharply fixed.

Relationship of the genus Kuehneola. J. C. ARTHUR

The affinities and autonomy of the genus Kuehneola have often been discussed. Argument is now presented to show that it belongs to the Melampsoraceae, among that shifting group of genera: Phakopsora, Schroeteriaster, Bubakia and Physopella. The genus has heretofore been associated with the aecidiaceeous genus, Phragmidium, from which genus it was originally segregated. A few species are considered still to have such affinity, and these are placed under a new generic name

Relation between storm and disease, August and September, 1915, in Texas. FREDERICK H BLODGETT

The Gulf storm of August 16 to 19 in Texas was characterized by an exceptionally heavy rainfall and by an unusually prolonged period of continued high wind. This resulted in correspondingly severe losses to the farmers with especial reference to the cotton crop which was just ready for the first picking. The impact of the rain driven by the high winds killed the foliage, but where rains followed later the same week new growth promptly replaced the blasted leaves. About two weeks after the storm complaints became numerous concerning the condition of the cotton bolls in the field, and specimens of anthracnose and bacterial spot were received in considerable numbers. A field inspection trip was made to determine the degree of injury wrought by the combined influence of storm and disease, and it was found that the area of most severe damage was within the region of greatest storm activity, and was practically bounded by the line denoting two inches of

rain falling during the twenty-four hours of the storm. A map has been prepared to show the coincidence of these areas, using the data of the weather service as to the storm factors.

Hard rot disease of gladiolus. L. M. MASSEY

During the last four years the writer has worked with a corm rot of the gladiolus. The corms become infected in the field. The rot advances during storage until by spring many corms are converted into hard, dry mummies. The lesions appear as small, olive brown, water-soaked areas. As the disease advances the infected area becomes sunken and very hard.

Although many isolations of the causal organism were made, and its pathogenicity established, no spore form of the fungus was observed until October 1914. In examining a culture of the fungus, Septoria-like spores were found. Mature pycnidia were then obtained by inoculating the foliage of large plants with mycelium isolated from a diseased corm. The writer had previously noticed the similarity of the mycelial growth of this fungus to that of *Septoria Gladioli* Passer. which was thought to occur only on the foliage of the gladiolus. Further investigation has shown these two organisms to be identical, and that to *Septoria Gladioli* Passer. must be ascribed the cause of the hard rot disease of the corm.

Steaming of soil for the control of root rot of ginseng. J. W. BRANN

Results obtained at Antigo, Wisconsin with steaming of soil indicate that this method is at least partially effective in controlling the brown root rot or "rust" of ginseng.

The inverted pan process as described by Gilbert was followed with such modifications as were necessary. Stratified seed and roots of various ages were planted following the soil treatment in the fall of 1914. Care was taken in selecting healthy roots for planting. Observation of the ginseng beds during the summer of 1915 showed that the plants in the steamed beds not only had less rot, but were more vigorous than those in the control beds.

The physical condition of the soil was improved and this, no doubt, was an important factor in causing the increased vigor of the plants. Weeds were also held in check. More satisfactory results were obtained with light loam than with the heavier soils.

Comparative tests showed that from the standpoint of simplicity, cost of operation and effectiveness, this process is far superior to soil treatment with formaldehyde solution for control of ginseng brown root rot.

Additional benefits from steaming in controlling other diseases of ginseng may be derived.

A wilt disease of the columbine. J. J. TAUBENHAUS

As far as can be ascertained from literature, no Sclerotinial disease is reported to occur on the columbine. A very serious wilt disease was found in the spring of 1913 on a columbine plantation at the flower garden of the Delaware College Experiment Station. The trouble in this case was directly introduced with the manure which was used as a mulch around the plant the previous winter, and which was not removed in the spring. The fungus causing the disease attacks the crown, then the stem and causes a gradual wilting and drying of the plant. The roots are not affected. Pure cultures of the fungus were obtained and the disease reproduced artificially on healthy columbine plants grown in the greenhouse. The sclerotia of the fungus were obtained in large numbers from the interior of dead vines. These

were wintered over in the usual way, and the perfect stage produced. The measurements of these asci and ascospores and the pure cultures from the latter agreed with the description of *Sclerotinia libertiana* Fckl.

Fourth progress report on Fusarium resistant cabbage. L. R. JONES

The previous reports (PHYTOPATHOLOGY 4: 404, etc.) have shown the high resistance of certain selected Hollander cabbage strains when grown in Wisconsin. Trials on the same "sick" soils in 1915 confirmed these results, although the cool summer gave less yellows than 1914. Even more significance attaches to the cooperative trials made under the auspices of the United States Department of Agriculture in other states; in Delaware under Manns, in Ohio under Selby and Humbert, and in Iowa under Fitch. All showed that selected Wisconsin-grown seed retained its resistance to yellows when grown elsewhere. Mann's observations indicate a possible resistance to Phoma wilt also. Over one hundred pounds of seed of the resistant strains was grown in Wisconsin this last summer, of which twenty-five pounds is of the best head strain "Wisconsin Hollander No. 8." Parties in other states wishing to make trial of this in 1916 should apply promptly for seed. It should be noted, however, that, although the cabbage Fusarium is widespread in the United States, the practical usefulness of these selected Hollander strains is probably limited to the northern states unless it be as a parent stock for further breeding or selection. Middle and southern states require earlier varieties. Selections have been made to meet these needs and will be continued in cooperation with the above named state and national officials. The most promising new thing tried this year is a selected headstrain of Brunswick, a favorite Wisconsin kraut cabbage. This gave on "sick" soil 18 per cent yellows, 100 per cent stand, and 95 per cent heads, while commercial controls alongside gave 84 per cent yellows, 85 per cent stand, and 76.1 per cent heads. Further selections from this and other kraut and earlier varieties have been sent south along with selections by the other cooperating parties for an attempt at seed growing this winter in the hope thereby to save a year's time.

A new method of testing for wilt resistance and for selecting wilt resistant strains of tomato. C. W. EDGERTON

To test the wilt resistant qualities of a variety or to select wilt resistant individuals, it has been necessary, in the past, to grow a large number of individuals in the field. A new method for tomato wilt has been devised whereby the tests and selection work may be conducted in the seed-bed, thus saving considerable time and labor. The soil in the seed-bed is first sterilized by heat and then heavily inoculated, just previous to planting the seed, with pure cultures of the wilt fungus. Susceptible plants growing in seed beds treated in this manner will succumb with the wilt disease from three to eight weeks after planting, while plants in unsterilized soil will not be appreciably affected until after planting in the field. This method is very serviceable for testing the comparative resistance of different varieties, for testing the comparative virulence of different strains of the pathogene, for testing the effect of different soils and fertilizers on the disease and for selecting wilt resistant plants in breeding work.

A newly noted Phyllosticta on alfalfa in America, and its ascigerous stage. FRED REUEL JONES

During the past two summers a yellow leaf blotch disease of alfalfa has been under observation in fields about Madison, Wisconsin, and has been noted in Indiana,

Illinois, Minnesota, South Dakota, and Iowa. The blotches are elongate in the direction of the veins, of a pale yellow color on young leaves, and become deep orange on older leaves. In the infested tissue are constantly found numerous pycnidia of a fungus which appears to be *Phyllosticta Medicaginis* Fckl. Repeated attempts to germinate the conidia, or to infect healthy plants with them have been unsuccessful.

During the past autumn it was observed that the dead leaves on plants which had been infested with this Phyllosticta earlier in the season turned dark, curled up in a characteristic manner, and bore on the under surfaces abundant apothecia of a discomycete which appears to be *Pyrenopeziza Medicaginis* Fckl. Ascospores discharged from these germinated readily. Alfalfa leaves were inoculated repeatedly with the discharged ascospores. The characteristic yellow blotches with abundant pycnidia developed uniformly. Leaf fragments cut from these blotches, sterilized superficially, and placed in culture tubes on suitable substrata have developed the Pyrenopeziza.

These results, and evidence obtained from studies now in progress, indicate that the Phyllosticta is the conidial stage of the Pyrenopeziza.

The development of Mycosphaerella pinodes in pure culture. R. E. VAUGHAN

In connection with pea blight studies carried on at Wisconsin since 1911 *Ascochyta Pisi* Lib. and *Mycosphaerella pinodes* Stone have been constantly associated with diseased vines. In field and greenhouse experiments plants inoculated with Ascochyta have developed this fungus and later Mycosphaerella has been found on the same lesions. Plants inoculated with Mycosphaerella have also developed Ascochyta and Mycosphaerella.

The ascogenous stage of the fungus has now been produced in pure culture under the following conditions. A single spore of *M. pinodes* was isolated by the Keitt method and planted on potato agar. From this culture the perfect stage of the fungus has been again secured by two methods as follows: (1) Transfers were made to green pea leaves which had been sterlized in corrosive sublimate, washed in sterile water and placed in a sterile condition on freshly poured plates of potato agar. Temperature 20°C.; growth rapid and profuse; pycnidia with spores developed on leaf and surrounding agar. After 30 days black perithecia were observed scattered among the pycnidia on the leaf but not on the agar. These contained asci and spores of *M. pinodes*. (2) Transfers to tubes of potato agar were held at 20°C. for 30 days and 11°C. for the next 110 days. Examination then showed them to contain fruiting bodies of both Ascochyta and Mycosphaerella.

Leaf smut of timothy. GEO. A. OSNER

Leaf smut of timothy, caused by *Ustilago striaeformis* (West.) Niessl, has been very abundant in the timothy fields of New York and northern Indiana during the past two seasons. Out of a large number of meadows examined in several different counties, not one was found entirely free from the disease, the loss varying from very slight up to 30 per cent. In Genesee County, New York, where the most complete survey was made, the loss in 1915 was estimated to be about 4 per cent.

During the summer of 1914 several series of inoculations were made to determine the manner of infection. The following methods were tried: (1) inoculating the seed with spores, both fresh and old; (2) inoculating the blossoms; (3) inoculating the soil and sowing seed after varying lengths of time; (4) inoculating growing tissues directly. Where the checks remained healthy, infection occurred only in the case of blossom inoculation.

Experiments have been conducted on the control of this disease by seed treatment with formaldehyde solution, copper sulfate solution, and hot water. The formaldehyde and copper sulfate solutions failed to control the disease but perfect control was obtained by means of the hot-water treatment.

Some root diseases of the bean. W. H. BURKHOLDER

An investigation of a serious disease of the bean (*Phaseolus vulgaris*) in western New York was undertaken during the summer of 1915. The disease is manifested, principally in a yellowing and dropping of the leaves, and a failure to set pods. Examinations show that this trouble is due to an affection of the roots and of the stem underground. A week or so after the bean plant has appeared above ground a discoloration of the tap root is noticed. The disease spreads slowly, killing the lateral roots, the lower ones first and extending in red streaks a short distance up the stem. A great many surface roots are developed above the diseased area. A field of beans which gives promise of a fair yield in July, may prove a failure at harvest time.

The trouble is due to several causes, the primary one being a species of Fusarium which attacks the underground parts. *Thielavia basicola* was found generally upon the bean root and in a number of cases, Rhizoctonia was found.

Inoculation experiments gave positive results with all three organisms, a somewhat different lesion being formed by each.

Inoculation experiments with the Fusarium upon the various crops grown in rotation with the bean all gave negative results. The pea (*Pisum sativum*), red clover (*Trifolium pratense*), alsike (*Trifolium hybridum*), and alfalfa (*Medicago sativa*), proved susceptible to *Thielavia basicola*. The species of Fusarium seems to be distinct from any that has been described previously on the bean.

Two interesting diseases on greenhouse tomatoes. MEL T COOK AND C A. SCHWARZE

A leaf spot on greenhouse tomatoes has been studied The trouble originates as small circular spots which enlarge, become grayish brown and show concentric, somewhat irregular circles very similar to *Macrosporium Solani*. Small, blackish pustules, visible under the hand lens, exude whitish strings of spores. The fungus corresponds with the description of *Ascochyta Lycopersici* recorded by Saccardo on weakened plants in Italy and in France. Puncture inoculations from cultures reproduced the typical disease. It is evidently a weak parasite.

A fruit rot was first observed on ripe and semi-ripe fruits, starting at the blossom end. The diseased fruits were soon covered with a dense grayish mass which proved to be a Botrytis. This rot was very generally restricted to fruits with a rough or creased blossom end and rarely occurs on smooth fruits. A further study showed that the old blossoms so commonly found clinging to the fruits usually contained the fungus. Fruits from which the corollas dropped early were rarely affected. When drops of water containing the spores were placed on the rough blossom end fruit, the rot developed very quickly. The same test with smooth tomatoes seldom gave a rot unless the epidermi was punctured. Dead blossoms placed on the rough blossom end of fruits and kept moist also gave the rot. In cultures the fungus produced large, black sclerotia. The symptoms are practically the same as have been described for blossom end rot.

Cucumber diseases in the middle west. W. W. GILBERT

An investigation of the cucumber diseases was begun the past season in Wisconsin, Indiana, and Michigan, in cooperation with the state experiment stations.

Extended observations during the past season in these and adjacent states brought out the following facts regarding cucumber disease occurrence.

The cucumber mosaic disease, commonly called white pickle, has been found causing serious losses in the states of Wisconsin, Michigan, northern Indiana, and Illinois, and is known to occur also in Iowa, Ohio, Vermont, New York, Minnesota, Massachusetts, and Virginia. This disease is comparatively new in its serious occurrence in the field and is being studied from the field standpoint by Mr. S. P. Doolittle of the Michigan Agricultural Experiment Station. Prof. I. C. Jagger, of Cornell University, has also been studying the disease as it occurs in the greenhouses in Rochester, New York. A description of the disease and a record of results of the preliminary work which has been done will be given elsewhere.

The scab (*Cladosporium cucumerinum*), caused quite serious losses to pickle growers in Michigan and occurred in a more limited way in Wisconsin, Indiana and Ohio.

Anthracnose (*Colletotrichum lagenarium*), occurred quite generally over northern Indiana, Wisconsin, and southern Michigan and did considerable damage, owing to the favorable conditions incident to a wet season.

The wilt disease (*Bacillus tracheiphilus*), occurred quite generally in Wisconsin, Indiana, and Michigan in the early part of the season but has not been considered a very serious trouble by pickle growers for the reason that most of the injury is done before the final thinning of the plants.

The angular leaf spot, a new and undescribed bacterial disease, which is now being studied by Mr. Eubanks Carsner in Wisconsin, occurred particularly in Wisconsin and central Michigan and in some cases caused serious defoliation of plants in affected fields.

Downy mildew (*Peronoplasmopara cubensis*) did practically no damage this season as it did not appear in northern Indiana until a few days before the cucumber plants were killed by frost.

A new infectious mosaic disease of cucumber. S. P. DOOLITTLE

To be published in full in the April issue of Phytopathology.

Experiments with the cucumber mosaic disease. I. C. JAGGER

To be published in full in the April issue of Phytopathology.

Angular leaf spot, a bacterial disease of cucumbers. EUBANKS CARSNER

A leaf spot disease of cucumbers, proved to be of bacterial origin, has been a subject of study in Wisconsin and elsewhere during the past two seasons. The disease is characterized on the leaves by rather sharply angular spots bounded by the larger veinlets. The spots have at first a watersoaked appearance and later become brown. Old diseased leaves often show a ragged appearance following the breaking away of dead parts. On both surfaces of affected areas, under moist conditions, a slightly viscous exudate containing bacteria has been repeatedly observed which, on drying, leaves a white residue. The disease often appears also as longitudinal lesions on the stems. The only similar disease which has been noted in literature is that described by O. F. Burger from Florida as a bacterial rot of cucumbers.

The angular leaf spot disease is widespread and destructive. The writer has observed it in Wisconsin, Virginia and Michigan, and has seen specimens of it from Illinois, Indiana and Iowa.

The causal organism has been isolated, used in pure culture to produce the characteristic disease and has been reisolated. It is rod-shaped and motile. The flagella are polar.

From preliminary experiments the disease seems to be held in check by spraying with bordeaux mixture.

Studies in the control of storage rots of the sweet potato. J. J. TAUBENHAUS

Careful investigations have shown that soft rot (*Rhizopus nigricans* Ehr.) is the greatest detriment to the keeping of sweet potatoes in storage. The losses from this disease run from 5 to 60 per cent. Next in importance is black rot (*Sphaeronema fimbriatum* (Hals.) Sacc.). The losses from this disease are comparatively small. The factors which favor soft rot are poorly ventilated houses. Rough handling of the crop at digging and storing as well as moist warm weather are also factors which interfere with proper keeping. These are conducive to soft rot. Overheating and lack of ventilation favor black rot. Storage men are beginning to realize the advantages of ventilation. Careful studies have shown that the average sweet potato house is poorly built and has poor facilities for ventilation. Hygrothermographic studies have shown that a relative humidity of over 70° in storage is detrimental. At present all types of houses good or poor depend on natural ventilation, hence the storage of sweet potatoes is precarious. Soaking the sweet potatoes with various strengths of copper sulphate, corrosive sublimate or formaldehyde proved ineffective in controlling the storage rots. Fumigation with sulphur and formaldehyde have not given results; however, the average sweet potato house is not tight enough to retain the fumes. It was apparent in previous studies that artificial ventilation and drying under moist and adverse weather conditions must be resorted to. An electric fan has been installed in one of the large commercial houses which offers an economical means of ventilation. Whether such an artificial system aided by heat from stoves will carry sweet potatoes through adverse conditions is to be determined.

Field studies on the Rhizoctonia of the potato. MEL T. COOK AND H. CLAY LINT

The Rhizoctonia disease of potatoes was very severe in New Jersey in 1915, causing (1) poor germination, (2) brown stem, (3) curly leaf (4) dwarfing, (5) aerial potatoes, (6) little potatoes, and resulting in (1) poor stands, (2) reduced yields and (3) in some cases complete loss of the crop The severity of the attack varied with seed from different sources as shown by field observations and planting on the Experiment Station farm. The results from seed treatment were variable but the corrosive sublimate was much better than treatment with formaldehyde.

A Fusarium tuber and stem rot of potato. R. J. HASKELL

During the past year the writer has isolated, from the fibrovascular bundles of potato tubers, a Fusarium which produces a very virulent stem and tuber rot.

After making sure that the cultures were pure, potato plants were inoculated by injecting, or inserting, spores and mycelium into the stems just below the level of the ground. Fifty plants both in the greenhouse and in the field, were inoculated and of these 80 per cent became affected. The tops wilted and died because of the rot at the base. Many of the potatoes from inoculated plants showed the characteristic rot in the region of the vascular ring, and some of them had a sunken, dry, stem-end rot. In no case did the checks show any of these symptoms.

The Fusarium apparently belongs in the section Martiella Wr. and is closely related to, if not identical with, *F. eumartii* Carpenter. It resembles the latter very much in its ability to rot potatoes in storage.

Infection and resistance studies of Phytophthora infestans on the tomato. I. E. MELHUS

Tomato foliage is readily infected with *Phytophthora infestans* of the Irish potato, but it has not been found possible to infect the fruit except through the peduncle, the calyx, or the epidermis when ruptured. Indeed when the epidermis of the fruit is intact, infection does not take place. The period of incubation is the same for the tomato and the potato, that is from three to six days, depending on moisture and temperature conditions. The fungus spreads and fruits more sparingly on the foliage of the tomato than on the foliage of susceptible varieties of potato, and to this fact are doubtless due the numerous contradictory statements relative to the identity of species of Phytophthora on these two plants. Livingston's Coreless and Carter's Sunrise tomatoes are susceptible, but less so than Green Mountain or Irish Cobbler, which are among the most susceptible varieties of potatoes. The Red Peach potato is very highly resistant, in fact more so than any of the specially resistant German varieties of potatoes, e.g., Apollo and Sophie.

Meteorology and late blight of potatoes. C. R. ORTON

The late blight of potatoes caused by *Phytophthora infestans* destroyed nearly one-half of the potato crop in Pennsylvania the past season. It has now been reported at State College and vicinity in 1891, 1910 and 1915. Of these seasons it was least destructive in 1910.

A study of the meteorological conditions which might permit an outbreak of late blight at State College appears to show that precipitation alone has little if any bearing on the problem. Neither do atmospheric temperatures alone or when correlated with precipitation appear to show much relation to outbreaks of Phytophthora.

Other factors which do appear to bear more directly on the subject are humidity and soil temperature. Low soil temperatures which approach the optimum temperature for the rapid development of Phytophthora in artificial cultures, are thought to be of importance in initiating an outbreak of late blight. High relative humidity the latter part of July and in August is possibly the most important factor in determining the rapid spread of Phytophthora to produce an epiphytotic.

The morphology and cytology of the sexual organs of Phytophthora erythroseptica. PAUL A. MURPHY

A study of sectioned and stained material has shown that the development of the sexual organs follows the course described by Pethybridge, the oogonial incept growing through the antheridium and forming the oogonium at the other side.

The incept has been found in the act of penetrating the antheridium, and numerous stages have been seen in the process of emergence and in its further development into an oogonium. The antheridium remains permanently clasping the stalk of the oogonium.

Meantime the greater number of nuclei in both organs have degenerated. The remainder divide once, mitotically and simultaneously. Immediately afterwards the cytoplasm of the oogonium is differentiated for a short time into ooplasm and periplasm with all the daughter nuclei lying on the line separating the two.

Fertilization takes place at this stage. A tube is pushed in from the antheridium

through that part of the stalk of the oogonium which lies within the male organ, and through it a single male nucleus and the greater part of the cytoplasm passes in.

The periplasm is absorbed before the wall of the oospore thickens, and fertilization is then completed by the fusion of the single male and female nuclei.

The effect of bordeaux mixture on the potato plant. B. F. LUTMAN

There seems to be a general agreement among all experimenters who have used bordeaux mixture on the potato in the northern states that the effects are beneficial to the plant. The European results are not always in accord with the American. From seven years trial in this country and from one in Germany, the author believes that the beneficial effects of the bordeaux can be ascribed to its prevention of: (1) The early appearance of tip-burn, (2) the greater part of the flea-beetle injuries.

Of these two effects, the former is much the greater. In spite of an increased general transpiration in the sprayed plants, the advance of the tip-burn is much slower than in the unsprayed ones. The cause of this retardation seems to lie in some sort of chemical union between the chlorophyl and the copper compounds. Sprayed plants unaffected by tip-burn do not produce more starch per plant than similar unsprayed ones.

Spongospora on the roots of the potato and on seven other new hosts. I. E. MELHUS AND J. ROSENBAUM

Spongospora is commonly considered a tuber disease, but in certain greenhouse experiments in 1914, involving the use of infected soil it was found that galls developed generally on all underground parts of the potato plant, and on August 5, 1915, this condition was found to prevail in the field also In the latter, it was found during the past season that fifty-seven days elapsed between planting and the first sign of infection. Where plants about half grown were transplanted from clean to infected land infection resulted in from fourteen to thirty-four days. The galls occur first on the very small rootlets, but later on are in evidence on the larger roots also. As many as two hundred and fifty galls have been found on the under ground parts of a single potato plant. The present investigation has shown that Spongospora has seven hosts besides the potato, that is, the tomato and six species of Solanum. The galls are much larger on some of these hosts than on the potato. The new hosts are as follows: *Solanum commersoni*, *S. ciliatum*, *S. marginatum*, *S. mammosum*, *S. haemotocladum*, *S. warsceunczii*, and *Lycopersicon esculentum*.

Two wild hosts of Bacterium solanacearum. H R. FULTON AND E. E. STANFORD

On land known to be infested with *B. solanacearum*, plants of *Ambrosia artemisiæfolia* L. and *Eclipta alba* (L.) Hassk. showed characteristic symptoms of the bacterial wilt or brown rot of Solanaceae. From these hosts a bacterium was isolated in pure culture, which, when inoculated by needle pricks, produced the disease on Ambrosia, Eclipta, tomato, tobacco, and nasturtium. The organism was reisolated from artificially inoculated plants and its identity with the inoculum proved.

Comparisons of strains of the bacterium from Ambrosia, Eclipta, tobacco, tomato and peanut showed agreement in cultural characteristics on various media. The reactions to ordinary stains were the same. The organism agrees in all essential respects with *Bacterium solanacearum* Erw. Sm.

Eclipta alba is susceptible and *A. artemisiæfolia* very resistant to this bacterium. Constant differences in virulence were apparent in strains of the organism isolated from different species as well as in those isolated from different individuals of the same species.

Life histories of Melanops. C. L. SHEAR AND MISS A. M. BECKWITH

Melanops from the following thirteen hosts have been grown in pure cultures from single ascospores and have produced pycnidia: *Aesculus hippocastanum, Cercis canadensis, Crataegus* species indet., *Juglans cinerea, Liquidambar styraciflua, Pyrus malus, Quercus* two species indet., *Ribes rubrum, R. oxyacanthoides, Robinia pseudacacia, Viburnum* species, and *Vitis labrusca.*

The cultures from Aesculus, Cercis, Juglans, Liquidambar, Pyrus (one collection), Ribes, both species, Robinia, and Viburnum produced Dothiorella micro- and macropycnospores.

The cultures from Crataegus, Pyrus (two collections), Quercus, two species, and Vitis gave Sphaeropsis of the *S. malorum* type.

In two instances, one from currant, *Ribes rubrum* and one from Viburnum, asci and ascospores, as well as pycnospores, have been produced in pure culture from single ascospores. One form from currant is chromogenic on certain media, as starch-paste and cornmeal, as has been described by Grossenbacher. A form from Viburnum is also chromogenic.

The taxonomic status of the organisms on the different hosts has not yet been satisfactorily determined. All of them are very similar morphologically and some of them have been referred to by the senior writer previously as forms of *Melanops quercuum* (Schw.) Rehm.

The perfect stage of Septoria ribis. R. E. STONE

As the result of three season's work the author has come to the conclusion that *Mycosphaerella grossulariae* (Fr.) Lind., is the perfect stage of *Septoria ribis* Desm.

The conclusions are based upon the following data:

Leaves of *Ribes nigrum* L., infected with *Septoria ribis* Desm., bear in the following spring and early summer an ascomycete which agrees with the descriptions of *Sphaerella grossulariae* (Fr.) Auserw., as given in Saccordo's Sylloge Fungorum and other works. It also agrees with *S. grossulariae* (Fr.) Auserw., on *Ribes nigrum* issued by Sydow as No. 581 Myc. Germanica.

The ascospores of the fungus found here, when planted singly in culture media give rise to colonies of Septoria. This Septoria, when sprayed upon the leaves of *Ribes nigrum* L., gives rise to typical leaf spots bearing typical pycnidia and spores of *Septoria ribis* Desm.

If leaves of *Ribes nigrum* L., are inoculated directly with the ascospores of the fungus, typical lesions and fruit bodies of the Septoria are formed.

In addition *Ribes rubrum* L., and *Ribes oxycanthoides* L., can be infected with the ascospores derived from the old leaves of *Ribes nigrum* L., and also by the Septoria spores either taken directly from the leaves of the black currant or derived from cultures resulting from germinated ascospores.

Ribes aureum Pursh does not seem to be susceptible to this particular Septoria.

Ascospore material has been collected at Guelph, Ontario, 1913, 1914, 1915, and by Mr. McCubbin of the Dominion Laboratories and the author at St. Catherines, Ontario, in 1915.

The only previous collection of *Sphaerella grossulariae* (Fr.) Auserw., in America on record is that by Professor Pammel in Iowa and reported in Bul. Iowa Agr. Exp. Sta 13: 70. 1891.

Phytophthora rot of apples. H. H. WHETZEL AND J. ROSENBAUM

Published in full in this issue.

Black root-rot of apple. H. R. FULTON AND R. O. CROMWELL.

This rot has been observed in serious degree at a number of points in Pennsylvania and North Carolina. The fungus causing it produces a dense superficial growth of mycelium that is at first white and later becomes a black incrustation. It grows readily on ordinary culture media. There is only a slight tendency towards rhizomorphic development. Spinulose terminals of the hyphae are characteristic. There are hyphal anastomoses. No spore production has been observed under either natural or artificial conditions. Pure cultures of the fungus readily produce characteristic rotting when introduced into bark wounds of apple roots. This rot may extend fourteen inches in twelve weeks, the spread being about equal distally and proximally from the point of inoculation. The bark is killed throughout, and the fungus threads penetrate the wood rendering it brittle. Complete disintegration is slow.

The fungus shows points of difference from those ordinarily recognized as root destroying forms. Its identity has not yet been determined.

Blister spot of apples. D. H. ROSE

During the summer of 1915 what seemed to be a new disease was observed on Early Melon, Ishewold and Hawley apples and on one variety in an orchard of French Dwarf apples. The disease consists of roughly circular, sometimes irregularly lobed shallow blisters varying in color from light brown to black and in size from one to five millimeters in diameter by one-half millimeter in depth. Poured plates from blisters on all the affected varieties gave after thirty-six hours nearly pure cultures of a motile rod 0.9 to 2.7 by .5 to .8μ. Colonies were pale white, usually about one millimeter in diameter. Free hand sections of blisters showed the organism present in large numbers in ruptured cells of the epidermis and the tissues immediately beneath it.

Throughout thirty series of cultures the writer found the following reactions consistently repeated: litmus milk turned blue in three days, then slowly decolorized from the bottom upward, casein slowly precipitated then gradually redissolved; gelatine liquefied after six or seven days; growth on potato moist, spreading, cream colored; acid from dextrose and saccharose, but none or very little from lactose, and no gas from any of them; fermentation results are from three tests only.

Inoculation by needle punctures gave typical blister spots in about two weeks on Early Melon, Ishewold, Yellow Newton and Jonathan. From these spots an organism was recovered, which, judging by its morphology, and cultural characteristics was identical with the one used for inoculation. Reinoculation with this second isolation again produced typical spots.

The investigation is being continued.

Apple scald. CHARLES BROOKS AND J. S. COOLEY

Experiments in progress indicate that humidity is more important than carbon dioxide in determining the amount of scald. Apples have been stored in unstirred atmospheres containing various percentages of carbon dioxide without the development of scald, while similar apples kept in saturated atmospheres in closed but unsealed moist chambers became badly scalded. Others kept open in stirred atmospheres of 40 per cent to 70 per cent relative humidity have not scalded. Neither

have others kept open in a stirred atmosphere in which the carbon dioxide was kept at 1½ per cent to 2 per cent. Apples have scalded more quickly at high than at low temperatures.

The results suggest the importance of cool temperature, and an open pack in the prevention of scald.

Irrigation and bitter pit. CHARLES BROOKS AND D. F. FISHER

A sort of corky pit is produced on the fruit of trees that have suffered from a sudden check in the water supply. The corky pit differs from true bitter pit in having much larger areas of dead brown tissue and in usually appearing earlier in the season. At first the spots are watersoaked and of irregular shape, often a reddish color, and usually give off drops of a yellowish sticky liquid that is sweet to the taste. In late stages of the disease the fruit is much misshapen, the spots hard and sunken and the flesh beneath the skin brown and corky like that of an old bruise.

True bitter pit increases with an increase in the irrigation water. Heavy applications late in the season have been especially harmful. The following results were obtained on Grimes Golden apples, the counts being made twelve days after picking:

Irrigation	*Per cent. of bitter pit*
Heavy throughout the season	43
Medium throughout the season	17
Medium until August, then heavy	49
Light throughout the season	14

Similar results have been obtained on Jonathans and other varieties.

Temperature relations of apple rot fungi. CHARLES BROOKS AND J. S. COOLEY

Apples with natural infections of bitter rot and black rot were stored at various temperatures. The development of bitter rot was slow at 15° C., rapid at 25°, and slow at 30°. It was completely inhibited at 0°, 5°, and 10°, but after two months' exposure to these temperatures developed rapidly when removed to 25°. Black rot developed rapidly at 25°, but at the end of ten days had made but little progress at 10°. After two months' time it had made considerable development even at 0°.

Apples were inoculated with various fungi that had been isolated from decaying fruit. In two weeks' time little or no rot had developed with any of these at 0° or 5°. Monilia had made a very rapid growth at 10° and *Penicillium expansum* a medium growth. Botrytis had made a good growth at 15° but little at 10°. Sphaeropsis, Glomerella, Alternaria, and Cephalothecium had made but little development at 10° and 15°, but had grown rapidly at 20°. Neofabraea, Volutella, *Fusarium radicicola* and *Pestalozzia funerea* made but little growth at 15° and only a fair growth at 20°.

In flask cultures the growth of the above fungi, as shown by dry weight, was closely parallel to that on the fruit.

Brown blotch of the pear. G. W. MARTIN

This disease, which causes a serious disfigurement of the pear, has been present in orchards of New Jersey for a number of years, but because of its resemblance to the russeting which is a characteristic feature of many pears belonging to the Oriental group, has not been recognized as a pathological condition. The fact that the disease is readily controlled by spraying seemed to indicate that it was of parasitic origin and further study showed its constant connection with a fungus apparently

identical with one described under the name *Macrosporium Sydowianum* Farneti as causing a similar disease in Italy.

The direct damage is confined to the epidermal layers of the fruit. Besides the unsightly appearance of the diseased fruit, its keeping qualities are seriously impaired, and in the more severe cases scabby growths and deformities result.

The disease is readily controlled by two late treatments of spray.

A preliminary report on investigations of leaf spot of cherries and plums in Wisconsin. G. W. KEITT

During the past season, a field laboratory was maintained at Sturgeon Bay for studying certain leaf diseases of cherries and plums.

Cylindrosporium spp. were found to be the most seriously injurious leaf parasites of *Prunus* spp. in the sections studied. Cylindrosporiums were isolated from cultivated cherries and plums and from numerous wild species of Prunus. The relationships of these fungi to the various hosts and to one another are being studied.

Especial attention was devoted to a study of the life history of *Coccomyces hiemalis* Higgins in relation to the course and the prevention of leaf spot of sour cherries. Ascospores were found to constitute the source of primary infection. They were produced in great abundance upon the overwintered leaves on the ground. No evidence of discharge of ascospores was observed under field conditions until most of the petals of *P. cerasus* had fallen. Subsequently, under favorable conditions they were discharged abundantly throughout the spring and early summer. The disease was satisfactorily controlled on sour cherry trees which received their first application of spray when the petals were three-fourths off. Similar unsprayed trees were practically defoliated. Field observations strongly indicate that, under Wisconsin conditions, it is feasible greatly to reduce primary infection by early spring plowing and the disposal of leaves on the unturned soil about bases of trees before ascospores are liberated.

A convenient little-known method of making micro mounts of fungi. F. L. STEVENS

A description and demonstration is given of a modification and adaptation of a celloidin method of mounting fungi described by Gaillard, also used by Buscalioni.

The process consists in placing a drop of 4 per cent celloidin upon the fungus, allowing it to dry, lifting it off with forceps, dehydrating and clearing and mounting in balsam.

The method is particularly adapted to superficial fungi such as the Erysiphaceae, Microthyriaceae, Perisporiaceae. But it is useful also with the Moniliales, Uredinales, and so forth, and in the study of agar plate colonies.

The parasitism of Valsa leucostoma. R. C. WALTON AND D. C. BABCOCK

The seriousness of the disease caused by *Valsa leucostoma* in Ohio in 1915 prompted the writers to conduct a series of experiments with the fungus. Numerous inoculations made with mycelium from culture into peach branches, and peach and plum fruit, resulted as follows: (a) Inoculations made in the trunks and larger branches of living peach trees gave 100 per cent infection. Cankers were formed averaging 2.8 by 1.6 inches in one month's time, with the formation of pycnidia. (b) Mycelium placed over lenticels, without artificial wounds and covered with moist cotton, produced no infection. (c) Peach fruit, both green and ripe, inoculated with mycelium gave 94 per cent infection. (d) Plum fruit inoculated with mycelium gave 97 per cent infection. (e) Inoculations made in tips of peach branches gave 85

per cent infection. (f) Practically as many checks as inoculations were made, and these in all cases remained free.

Exudation of gum was plentiful on apparently healthy peach branches and trunks. Several specimens collected and cultures made from beneath the gum, after sterilizing the surface of the bark, showed that 41.2 per cent were infected with this fungus. Although there are other causes of gum flow, our experiments lead us to believe that many of the gum exudations are incipient infections of this disease.

Bacillus amylovorus in honey and in honeydew. H. A. GOSSARD AND R. C. WALTON

Honey obtained from beehives at various intervals during the spring and summer of 1915 was sterilized and inoculated with *Bacillus amylovorus*. After incubating from 8.5 minutes to several days in both pure and 50 per cent honey, the organism was cultured by the poured plate and streak methods on 3 per cent neutral nutrient glucose agar. One hundred and seventy-six cultures were made and *B. amylovorus* growth obtained repeatedly up to and including 43 hours and 25 minutes after infection. This isolated organism was then inoculated into the growing tips of apple shoots with 100 per cent infection resulting.

A fresh culture of *B. amylovorus* was inoculated into a test tube of unsterilized honey and incubated there for from 4 to 47 hours. At the end of the 4th, 28th, and 47th hour, inoculations were made from the infected honey directly to the tips of apple shoots. These inoculations gave 84, 64, and 52 per cent infection respectively, showing conclusively that the blight organism can remain sufficiently virulent in honey for at least 47 hours to produce infection.

Drops of aphid honeydew on apple leaves were infected with *B. amylovorus*. Inoculations were then made with the honeydew at the end of 20.5 hours, 43 hours, and 71.3 hours into apple shoots, using the infected honeydew as the inoculum. These inoculations gave 66.6, 83.3, and 100 per cent infection respectively.

Reisolations were made in many cases from the diseased shoots previously inoculated, and the indentity of the organism proved by cultures and microscopic examination.

Dusting nursery stock. V. B. STEWART

During the summer of 1915 experiments were conducted to test the relative value of dusting and spraying for the control of a number of leaf diseases of nursery stock. The experiments included the following: *Coccomyces hiemalis* and *Podosphaera oxyacanthae* on cherry; *Guignardia Aesculi* on horse-chestnut; *Pseudopeziza Ribis* and *Septoria Ribis* on currants; *Sphaerotheca pannosa* var. *Rosae* on Crimson rambler. Only a few hundred plants were included in each experiment. Four applications were made for the control of rose mildew. For the other diseases six to seven applications were made. The dusted plats were treated with a dust mixture of ninety parts sulfur and ten parts powdered arsenate of lead. Lime-sulfur solution, one gallon to fifty gallons of water, was used in the sprayed plats. In all cases the dust mixture was as effective as the lime-sulfur solution. The dust mixture was slightly more effective than lime-sulfur on horsechestnut and currant stock owing to the better distribution of the fungicide on the foliage. The results obtained warrant further experiments conducted on a more extensive scale.

Some new strawberry fungi. F. L. STEVENS AND ALVAH PETERSON

Rots of the ripe strawberry caused by several fungi are described and the characters of the fungi both in nature and in pure culture discussed. The following fungi are considered: *Sphaeronemella Fragariae* n. sp., *Patellina Fragariae* n. sp., *Botrytis cinerea*, *Sphaeropsis malorum* and *Rhizopus nigricans*.

Eradication of Cronartium ribicola from European pine plantings in New York State. W. H. RANKIN

Forty-seven plantings out of the original seventy-nine plantings of European white pine in New York have shown no diseased trees. Eighteen of these are now released from inspection as free from the disease. In thirteen no species of Ribes were ever found in the immediate vicinity. The other twenty-nine will be inspected in the autumn of 1916 to see if any trace of the telial stage is to be found on neighboring species of Ribes and then released if found free. Obviously these plantings are no indication of the effectiveness of the eradication methods used.

The thirty-two plantings which have shown diseased trees at some time or other since 1909 are divided into two groups: (1) sixteen plantings showing diseased trees only before 1913, eleven of these in 1910 only, and (2) sixteen plantings showing diseased trees since 1913, twelve of these both before and after 1913 and four after 1913 only. In the sixteen which have been free since 1913, eleven since 1910, eleven showed only either one or two diseased trees. Apparently the inspections and eradication methods have proved effective in eradicating the fungus in these sixteen plantings. However, in the other sixteen plantings, nine have shown an increase in the number of diseased trees found since 1913 and seven a decrease. It is believed that in fourteen of these sixteen plantings the fungus has passed from pine to species of Ribes and back to pine. Evidently the eradication has not been effective in one-half the plantings where there was anything to gain by inspection.

Eradication on a large scale. EDGAR NELSON

The attempt in Florida to eradicate citrus canker, a disease attacking citrus trees and fruit, is unique in plant pathological history because of its magnitude and the drastic methods employed by state authorities in their endeavor to wipe out the most dangerous enemy to citrus culture as yet known.

A year ago plant pathologists doubted the wisdom of the methods adopted by the state in its efforts to eradicate canker. Destruction by fire of trees, some yielding many boxes of fruit each year, seemed too radical a method to follow especially as the disease was a new one and just being studied. However, the discovery by Miss Hasse that the causal organism was a bacterium, *Pseudomonas Citri*, and not the fungus Phyllosticta, only justified this drastic measure. The work of eradication has been continued by the state which is determined to become free of this dangerous disease.

Trained inspectors examine the trees and destroy all infections with fire. Kerosene mixed with crude oil is sprayed on the tree. When this spray is ignited a flame of intense heat soon consumes the tree. Great precautions are taken to sterilize everything employed in infected areas as canker is very contagious.

A Gloeosporium on horse-chestnut shoots. J. F. ADAMS

In May 1915 the writer's attention was called to the blighting of terminal shoots of several horse-chestnut trees, *Aesculus hippocastanum*. Specimens were collected and on examination the shoots were found to be killed back for several inches from the terminal bud. The diseased tissue was somewhat shrunken and the epidermis ruptured by numerous scattered acervuli with conidia of the Gloeosporium type

Specimens placed in moist chamber developed profuse pinkish exudations of conidia from which pure cultures were procured. Growth in cultures was similar to that usually produced by Glomerella from apple developing numerous scattered

acervuli but no setae were found. Cultures two weeks old developed perithecia and ascospores. Inoculations on apple have produced a typical rot with characteristic development of acervuli and conidia similar to *Glomerella cingulata* with perithecia developing later.

The species differs from *Gloeosporium carpigenum* Cke., the spores of which are described as issuing in whitish tendrils on the fruit of *Aesculus californica*. In this species the spores are smaller and pinkish in mass. Further investigations are under way to establish the degree of parasitism of the fungus.

Inoculation studies with Neofabraea malicorticis. H. S. JACKSON

An extensive series of inoculations on apple trees with cultures from both the conidial and ascogenous stages of *Neofabraea malicorticis* (Cordley) Jackson, derived from apple, pear, and quince were made in the fall of 1913. The cankers developed from these inoculations have been studied through two seasons. The results confirm and extend the previous report of the genetic connection of *Gloeosporium malicorticis* Cordley with Neofabraea, made by the writer at the Washington meeting of the American Phytopathological Society (Dec. 1911) and published in the First Biennial Crop Pest and Horticultural Report of the Oregon Experiment Station (Jan. 1913).

Longevity of Bacillus amylovorus. J. W. HOTSON

On account of differences of opinion among certain fruit growers of the Yakima Valley, Washington, as to the length of time the fire blight organism lives in infected branches after they have been cut off, an effort was made to obtain some information regarding what actually occurs in the orchard. The object of these experiments was to determine how long the organisms live in the dried-up exudate when exposed to the direct sunlight, and also in infected branches when they are thrown down in deep grass or on soil in clean cultivation.

It was found that the organisms existing in the exudate on branches when exposed to direct sunlight on dry sunny days remained alive from ten to thirteen days according to the amount of exudate present. About the same results were obtained when the exudate was on the fruit. In positions where the branch was shaded part of the day, being exposed to direct sunlight about half time and diffused light the other half, the bacteria lived twenty-seven days in the bark. When exuding branches were left on the ground in an orchard, in which clean cultivation is practiced, the living organisms were obtained after fifteen days, while in infected branches left in an orchard where there was a cover crop of alfalfa, living bacteria were obtained in some cases twenty-nine days after the limbs were cut.

Observations on fire blight in the Yakima Valley. J. W. HOTSON

During the summer of 1915 a number of very peculiar conditions were observed in the study of fire blight in the Yakima Valley, Washington:

1. Fire blight on the cherries has already been recorded in the December number of Phytopathology.

2. Fire blight has been shown to gain entrance to the host through the leaves. These infected leaves, mostly Bartlett pears, turn brown in sections, the brown areas always including a portion of the margin of the leaf. The diseased leaves resemble sun scald in appearance.

3. A red streak similar to that found in connection with fire blight has been observed in the sapwood of Comice and less frequently, in Bartlett and Winter Nelis pears. In some instances *Bacillus amylovorus* has been definitely associated with

the streak, the organism, however, never being found near the extremity of the coloration.

4. Fire blight has been found frequently as twig infection on the Yakimine, a cross between a prune and a peach.

5. An abnormal amount of fruit infection was observed, it being out of all proportion to that found on the twigs and trunk. This increase was traced in some orchards to the fresh wounds made in thinning the apples.

A new species of Melanconium parasitic on the tomato. W. H. TISDALE

The disease was first observed in January, 1915, on both green and ripe tomato fruits in the horticultural greenhouse of the University of Wisconsin. It is characterized by small, dark brown to black spots which are largely superficial and not more than one-eighth of an inch in diameter when the fungus does not enter through wounds. In case of wound infection however the invasion proceeds more rapidly and the spots become sunken and are dark brown with concentric markings. A single spot may involve the entire side of a fruit, resembling very much the spots caused by *Gloeosporium phomoides* Sacc., the common tomato anthracnose. The disease is much more destructive to green fruits than the Gloeosporium disease.

The fungus was isolated and grown in pure culture. Inoculations were made on green and ripe tomato fruits both by wounds and by spraying the unwounded surface with a spore suspension. Both types of spots were thus obtained and the fungus was reisolated in pure culture.

On the large, wound-infection spots small, single-celled conidia are produced abundantly in acervuli which break through the cuticle. The fungus fruits very freely on oat meal and tomato agar. Spore masses are black, although a single spore under the microscope transmits light and appears greenish.

The characters of the fungus correspond with those of the genus Melanconium. No record of a species of Melanconium parasitic on the tomato has been found in literature. A large number of species, mostly saprophytic, have been described, but the tomato parasite differs from these so widely in its mycological characters, to say nothing of its parasitic nature, that it appears to be an undescribed species.

Tip-burn in white pine. G. P. BURNS

The forest nursery of the State Forestry Department of Vermont consists of three sections. Sections one and two are located on a sandy plain. Section one is almost wholly unprotected while section two is protected by a board fence and a large white pine grove. Section three is about one-fourth mile distant and is protected on three sides by a high bank on which are large white pine.

In June, 1914, the foreman telephoned that the trees were dying by the thousands and "there will not be a seedling or transplant alive by tomorrow night at this rate." Sections one and two were seared and brown having changed in one day from a healthy green color. A careful examination showed that some of the lower spots in these sections were still green and that section three had not been injured in any way.

The author had one control station fitted with meteorological instruments in operation in section one. The instruments recorded velocity of wind, amount of sunshine, amount of rainfall, air temperature and soil temperature. A study of the data seems to indicate that the velocity of the wind was the deciding factor in killing half of the young leaves. The meteorological data for the week previous to the injury are shown in the chart.

Second progress report on disease resistance in tobacco. JAMES JOHNSON

In a previous report on resistance in tobacco to the root rot organism, *Thielavia basicola* Zopf., it was noted that the White Burley variety was very susceptible, and the Little Dutch variety very resistant to this disease. Further trial with these and a number of other varieties in Wisconsin and Ontario, Canada, during the last two years has shown that the standard varieties of tobacco as grown in the United States and Canada vary greatly in their degrees of resistance to this disease. To the most susceptible varieties may be added principally the Oronoco and Maryland groups of varieties and the Pennsylvania Broadleaf type. The Connecticut Broadleaf variety and a number of the coarser types of tobacco locally known as Big Seed or Hybrid tobacco are as a rule, very resistant to disease. The Cuban and Havana Seed groups possess an intermediate degree of resistance. It is important that resistant strains be developed within each of these susceptible and semi-resistant groups, as no other satisfactory means for the control of the disease appears to be at hand. The loss due to this disease of tobacco in the United States during the season of 1915 is conservatively estimated at from ten to twenty millions of dollars. Very encouraging results have been secured in selecting for resistance within the White Burley variety. Strains have been secured which yielded in some instances more than one hundred times as much as ordinary White Burley on diseased soil. The quality of these resistant strains of Burley is to all appearances satisfactory from a commercial point of view. Selection for resistance within cigar binder types, i.e., Havana Seed, has yielded less favorable results owing to the difficulty of combining the desired quality with resistance.

Septoria on barley. A. G. JOHNSON

While making observations on certain other barley diseases during the past two seasons, the writer has noted a Septoria on a number of varieties of barley at various points as follows: Brookings, Bruce, Highmore, and Aberdeen, South Dakota, Fargo and Williston, North Dakota, and Hayfield and St. Paul, Minnesota.

The attack of the fungus is chiefly on the leaf-blades; less commonly on the sheaths. The invaded tissues are killed. The attacked portions become yellowish to yellowish brown and vary in size and form from small, narrowly oblong areas, more or less limited laterally by the veinlets, to blotches of considerable size. These lesions not infrequently become confluent and jointly may involve the entire leaf-blade or sheath, or large portions of them. In the dead tissue of the blotches, scattered pycnidia are visible, with the naked eye, as minute black dots. The pycnidia are subepidermal and contain numerous slender slightly curved spores of the Septoria type. The fungus is apparently the same as that on wheat, which is widely distributed in this country, and which usually goes under the name *Septoria graminum* Desm. No cross-inoculations have as yet been made.

Further studies of plum wilt. B. B. HIGGINS

In continuation of the work of which a preliminary report was made before the Phytopathological Society at its meeting in Philadelphia, it has been found by inoculations in the greenhouse and in the field that the fungus to which the plum wilt disease was attributed is capable of infecting plums as well as other species of the genus Prunus and of producing typical symptoms of the wilt with final death of the trees. These experiments indicate that the fungus is a general wound parasite of woody plants, but it has not been found occurring normally in any plant outside the genus Prunus.

The fungus is referred to the genus Lasiodiplodia, and is closely related to *L. theobromae* and to *Diplodia natalensis;* but until a comparative study of these related forms can be made, it seems best to consider this organism as a new species.

Gummosis with special reference to plum wilt. B. B. HIGGINS

To the formation of gum in wood infected with the plum wilt organism is attributed two of the most striking phenomena connected with the plum wilt disease, that is the sudden wilting of the leaves on apparently healthy trees—presumably due to the sudden decrease of the water supply by deposits of gum in the conducting tissue—and the limiting of infection areas in young trees by gum deposit in the surrounding tissue.

The elementary cause of gum formation is rather obscure and has led to much and very divergent speculation. A considerable literature on gummosis in Prunus and other genera in which it occurs has accumulated during the last few years, some writers attributing the phenomenon to enzymatic activity and others asserting that it can not be attributed to this cause.

Notable among the recent contributions on this subject have been those of Sorauer and of Beijerinck. Sorauer, after much experimental production of gummosis, attributes it to excess of hydrolizing over coagulating enzyme, which excess prevents deposition of pectin as formed in the young growing tissue. Beijerinck says that it is a necrobiotic phenomenon produced by an enzyme set free when cells are killed by wounding or by parasitic organisms.

That gum formation is due to enzymatic activity there can be little doubt at present; but from published accounts of experiments of others and from personal observations, it seems necessary to assume that the enzyme forming zymogen is present in all living cells of the plants and breaks down, setting free the enzyme, whenever it comes in contact with certain chemicals, poisons produced by parasites in the tissue, or other stimulating conditions.

Arsenate of lead as a fungicide for apple scab. W. J. MORSE

In a series of apple spraying experiments covering four successive seasons, using the Ben Davis variety, very satisfactory results have been obtained with four pounds of paste or two pounds of dry lead arsenate alone in fifty gallons of water, when compared with lime-sulphur, bordeaux mixture and other fungicidal sprays. With one exception it has controlled scab on the fruit as well or better than did lime-sulphur combined with one pound of the insecticide to fifty gallons. Arsenate of lead produced little or no russeting of the fruit. With it the percentage of merchantable fruit always equaled, and three seasons out of four exceeded, by from 12 to 18 per cent, that obtained with lime-sulphur.

Laboratory experiments by Mr. M. Shapovalov failed to show for arsenate of lead such high fungicidal properties as the field experiments indicated. Germination of conidia of the fungus (*Venturia inaequalis*), placed in similar dilutions of the poison was reduced and retarded, but by no means prevented. Likewise adding arsenate of lead to culture media retarded but did not prevent entirely the growth of the fungus.

Seed and soil disinfectants for the Rhizoctonia disease of potatoes. W. J. MORSE AND M. SHAPOVALOV

These experiments, covering the work of two seasons, are the result of an opportunity offered by a combination of favorable soil conditions and a variety of pota-

toes particularly susceptible to attacks of Rhizoctonia. The seed tubers used bore numerous sclerotia of the fungus and came from plants which were badly injured by the disease for two successive seasons. The first year the plots were located on pasture land which probably had never grown a cultivated crop, the second on land which had been in grass for several years. Only chemical fertilizers were applied.

The results were essentially the same both seasons. Seed tuber treatment with corrosive sublimate was the most successful, but even this was far from efficient. Formaldehyde also materially increased the proportion of healthy plants as compared with the check. On the other hand, sulphur aggravated the disease. Sulphur in the row at the rate of 500 pounds per acre led to an increase of from 20 to 30 per cent of diseased plants.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

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[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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SOUR SCAB OF CITRUS IN FLORIDA, AND ITS PREVENTION

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With Four Figures in the Text

Sour scab is a disease of the leaves, twigs and fruits of certain varieties of Citrus having a strongly acid sap in their actively growing portions. On account of this characteristic the writer favors the term sour scab rather than "lemon" scab, a name given the disease by growers when the lemon was the chief commerical variety in Florida affected by the malady. Sour orange (*Citrus aurantium* var. *amara*), lemon (*C. medica* var. *Lemon*), citron (*C. medica* var. *genuina*) and so forth, are very susceptible to the disease and, under conditions that frequently recur in Florida, most commercial varieties of grapefruit (*C. decumana* var. *pomelo*) except perhaps Triumph, are apparently equally subject to it. At present sour scab in Florida is of most economic importance in its relation to the growing of grapefruit.

This disease is most commonly evident by the distorted appearance of leaves and by the warty, misshapen fruits. Conical elevations having grayish brown tips are usually abundant on young leaves and fruits that are severely affected. Some portions of the diseased leaves seem to grow faster than others and thus result in distortions. As the season advances most of the warty protuberances on grapefruit flatten out somewhat and their tops become more or less covered with dark-gray, flaky scabs. The warty roughenings that remained flat are often eventually wholly covered by those scabs (fgs. 3 and 4). During favorable seasons a dark-colored mold (*Cladosporium Citri*) develops dense stands of sporophores on many of these scabby surfaces and produces enormous quantities of dark spores. This fungus is usually considered the cause of sour scab, although it is often not present in scabby spots in early summer.

If persistent winds prevail during the early development of new growth, the tender expanding leaves are often slightly injured by rubbing against others. The portions thus affected may die and drop off, but they more commonly remain alive without continuing the normal growth, and thus

give rise to crippled and puckered leaves that are frequently mistaken for scabby ones. Fruits may also become misshapen or develop blemished rind owing to rubbing occasioned by wind.

CONDITIONS FAVORING THE DEVELOPMENT OF THE DISEASE

Sour scab may vary greatly in severity from year to year, and often from tree to tree. In some seasons its early stages indicate very heavy losses that subsequently fail to materialize; as the affected young fruits enlarge the conical warts may flatten out sufficiently to permit the marketing of the fruit.

The observations made during the past three seasons show beyond a doubt that even when located in the scabbiest groves, trees making only a slight early spring growth are never severely affected by the disease. Only an occasional leaf or fruit of such a tree may show traces of sour scab. Some of these trees develop a very strong first growth in some years and consequently may have a correspondingly severe attack of the disease.

Usually sour scab is most prevalent on grapefruit trees on soil furnishing abundant water throughout the year. It should be noted too, that such trees set fruit practically every season, if given proper care; and that they also grow faster and more per year than those on high-pine land. However, if the air is fairly dry and the weather mostly warm and bright during the development of the first spring flush, scab may fail to develop even in such moist and fertile localities, and in which most of the old leaves are scabby. On the other hand, the disease often becomes very severe in groves on high-pine land if the soil has been enriched by heavy applications of fertilizers high in nitrogen and the weather is cold and wet during the development of the first spring growth.

The stock on which grapefruit trees are budded also has a determining influence on the relative amount of sour scab that develops. The disease is more abundant on trees budded on rough-lemon stock than on those budded on sour-orange stock. However, this difference in the susceptibility of grapefruit buds may be simply due to the relative amount of early growth produced on the two stocks. It is a well known fact that, other things being equal, buds on rough-lemon stock outgrow those on sour-orange stock.

As the conditions just enumerated indicate, the fertilization and cultivation of a grapefruit grove is doubtless also of some significance in the development of sour scab, especially on the sandy, high-pine lands. As mentioned above, while most of the trees in a scabby grapefruit grove are putting forth a very strong early spring growth, a few trees scattered among the scabby ones, may grow but little in early spring and be free of

scab. These slow-starting trees may put on a heavy growth in late spring that nevertheless remains practically free of the disease. The weather in

FIG. 1 Sour scab may be fully developed on the first spring growth of grapefruit trees by the time the first blossoms open This photograph shows one open blossom and three blossom buds.

late spring is usually warm and bright, and both soil and air are less moist than during the early part.

Some trees in scabby groves, under observation during the past two

years, have retained the late-starting habit and remained practically free from the disease; others of the same variety appear to be variable as regards this characteristic. In some cases depressing effects of one season appear to induce late-starting the following season. In this connection it is of interest to note the possibility of selecting strains from each of the important commercial varieties of grapefruit, that possess this late-starting habit to a marked degree and thus avoid some of the trouble with this disease. Such strains appear to occur in some bearing groves of

FIG. 2. June-bloom oranges from sweet-seedling trees showing the presence of scabby warts on the fruit, but no trace of disease on the leaves.

the variety Marsh Seedless, and it seems worth while making tests for the constancy of the late-starting habit.

It is only a few years since sour scab was more appropriately termed lemon scab. In those days the grapefruit was more rarely attacked and usually only mildly. Subsequently grapefruit trees were substituted for most of the lemons, and the growers put their best efforts and most of the fertilizer on the grapefruit while the remaining lemon trees were neglected. At present one sometimes finds the lemon trees having only traces of the disease while nearby grapefruit trees may be very scabby. Under certain

conditions the June-bloom oranges also become scabby, while the leaves are scabless, as shown in figure 2. June-bloom grapefruits often become

FIG. 3. June-bloom grapefruit showing both flat scabby regions and scabby warts. No trace of the disease was present on what seemed to be the corresponding crop of leaves.

scabby also while the foliage produced at the same time is free of scab (fig. 3). From a report received from Cuba last year, it appears that on

that island the leaves of grapefruit may be free of scab while the fruits are seriously affected. Such a condition is also shown in figure 4.

In nurseries the disease often becomes destructive among sour-orange and rough-lemon seedlings, and sometimes among the young grapefruit buds. Such seedlings and small nursery trees sometimes become stunted to a marked extent by this disease.

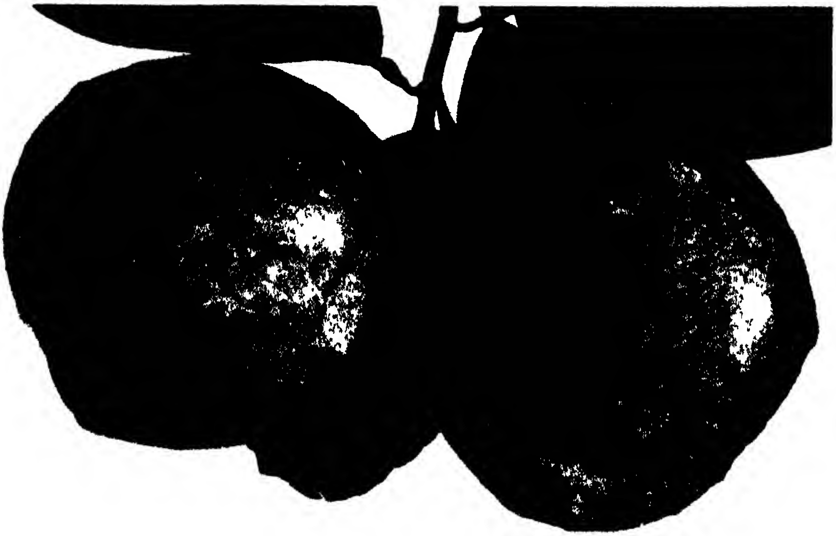


FIG. 4. Grapefruits of the crop of 1914, showing many flat scabby areas as well as warty protuberances. When these fruits were small they appeared more like those shown in figure 3.

THE FINANCIAL LOSS DUE TO SOUR SCAB

The annual loss from sour scab in Florida is heavy. In 1896, Swingle and Webber[1] estimated that the lemon industry sustained a loss "not far from $50,000." At the present time the loss in Florida alone sometimes is as much as a half million dollars a year on account of scabby grapefruit. In Cuba, Porto Rico, and the Isle of Pines the disease is often even more serious than in Florida. This is a heavy tax on the grapefruit business of the state, and one that can at least be partly avoided.

[1] Swingle, W. T. and Webber, H. J. The principal diseases of citrous fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. Path. Bul. 8: 21-25. 1896.

THE CAUSE OF SOUR SCAB

The conditions mentioned above as being commonly associated with the development of sour scab in grapefruit groves bring out many points of interest in regard to the cause of this trouble. When these data are considered in connection with the distribution of the disease in citrus sections, it appears that the moisture relations must be given prominence. It is evident that the development of the trouble is somehow dependent upon the presence of abundant moisture in the soil or air, or in both.

While the leaves of sour-orange, rough-lemon, and grapefruit are emerging from the bud, and during their period of rapid expansion, they usually become more or less thickly speckled at night with drops of moisture. When the leaves are larger both sides accumulate moisture. The amount of water thus accumulating apparently by both exudation and condensation, on expanding leaves seems to vary with the change in the humidity of the air. When the humidity is near the dew-point the small drops often become confluent and cover most of the surface of these leaves, and if the air continues moist the under sides of such leaves may remain moist several days at a time, while in periods of low air humidity the excessive moisture accumulated over night, evaporates early the next day. Until the leaves are fully grown water more readily covers them because they lack the waxy cover of fully developed leaves. During the early spring of 1915 the air was very moist and cold while the first growth was in its early stages and as a result sour scab developed in great abundance even on high sandy land if the growth was early and vigorous.

It is a well known fact that the acidity in growing plants is higher at night and during cloudy days, or when the weather is cold and wet than it is while the sun shines. Therefore the question may be raised: Do the excessive acidity induced by wet, cold weather and the resulting high osmotic pressure have a causal relation to the development of the disease? It is an interesting fact that the above mentioned water accumulating on expanding young leaves is neutral as far as can be determined by the litmus test.

When growing actively, the varieties of Citrus which are most subject to this disease emit a rather strong aroma suggestive of acid. Since the presence of a film of water on such developing growth seems to be a requisite for the development of sour scab, it seems probable that at night or during the time such aqueous films cover the expanding leaves, some of these exuded aromatic substances are absorbed by the water. In certain environmental conditions the oil-glands seem to become large and distended just as though the production of oil were exceeding their capacity. Under such conditions the amount of aromatic substances emitted is doubtless

more than it is under lower hydrostatic pressure. Consequently if this water film is retained during considerable periods at a time it may accumulate enough of these substances to cause mild injury and local stimulation of growth. Besides, experience with deciduous fruits indicates that the long-continued presence of liquid water on fruits may apparently by itself induce injuries like russetting of apple and pear. Citrus seems to be subject to such injuries only while the waxy cover is yet thin or wanting.

When the embryonic leaves of vigorously growing sour-orange or grapefruit trees begin expanding, the oil-glands, as mentioned above often protrude greatly above the outer surface of the emerging leaves. In some cases a few of these protruding oil-glands may break open, thus giving rise to crater-like conical elevations, the upper margins of which grow more or less and tend to close the pit. In cases in which the base of such a papillum grows very strongly the former oil-gland becomes elevated on a conical growth of superficial tissues and its tip becomes covered by flaky epidermal fragments arising in what was formerly the crater-like depression of the broken oil-gland. If the tissues surrounding the base of such a ruptured oil-gland fail to grow very strongly no elevation above the general surface results. Instead the rapid expansion of the surface of the affected leaf or fruit causes the place of rupture to cover a large area. This area arising by the expansive growth of the basal portion of the broken oil-gland, is largely or wholly covered by flaky, dead scales developed from subepidermal cells (fig. 2). As a matter of fact, these are only two of the simplest types of growth on citrus leaves, fruits, and twigs that are usually called scab. The growth forms are various, and intermixed to a great extent (compare figs. 2, 3, and 4). The surfaces of the warty growths are smooth where they are covered by normal epidermis, and rough where they are covered with an admixture of tiny dead scales and rough growth, regenerated in regions of primary injury (figs. 3 and 4). The irregularities are greatly increased by the subsequent rupture of other oil-glands as the leaf expan ls. It seems that the oil from the broken glands injures and often kills the epidermis around the openings. The writer has been unable to establish definitely what substance present in the young oil-glands induces the injury and the hypertrophy resulting in warts. The main constituents usually derived from orange oil such as limonene, anthranilic acid, anu methyl anthranilate, when applied to leaves and the bark of young branches, even in slight quantities with an atomizer, cause serious injuries, yet these compounds are apparently neutral to litmus. When the oil-glands of orange and grapefruit are punctured with a very fine needle and the oil is allowed to overflow the rind of the immature fruit or the epidermis of the leaf, the outer layers are injured or even killed over practically the entire area touched by the oil. Unfortunately, the

work could not be completed so that much remains to be determined, especially regarding the development of scabby warts from injured oil-glands in the more acid varieties of Citrus. Some inferences are based on unsubstantial evidence, because of the necessity of closing the work. These observations and some ideas they suggest are recorded so that in future studies consideration may also be given them.

The above-mentioned cultural methods as well as the weather seems to have much influence on the development of excessively large oil-glands in the early stages of vernation, and it seems that excessive moisture later in the season or when the tissues are older, also leads to the development of dermal injuries which appear to arise about broken or distended oil-glands. The diseases known as melanose and ammoniation seem to develop in that way. The appearance of these maladies differs from scab, however, in that instead of warty outgrowths, small brown elevations and gummous patches arise that make the affected surface feel like very coarse sandpaper. The ammoniation of oranges may probably be induced in several ways, but one of the simplest methods consists in fertilizing the trees heavily with nitrate of soda in spring and again in late May; yet this method is successful only *in case heavy rains fall in mid- and late summer.* Attention was called to the more important of these facts in a former paper,[2] in connection with decay of the fruit.

It is an interesting fact that sour scab has always been attributed to the fungus, *Cladosporium Citri*, and that *some* of the inoculation experiments performed by Fawcett[3] upheld the assumption that this fungus is the cause of the disease, while others were either negative or neutral. The statements by Scribner[4] and later by Underwood,[5] to the effect that the disease is due to a species of Cladosporium, are insufficiently supported by evidence. The writer's observations on the development under field conditions of this disease in 1913 and 1914 made him doubt the correctness of this hypothesis; and the inoculation tests made in the spring and summer of 1915, with spore suspensions from both pure cultures and from numerous leaves having great quantities of viable spores of the fungus on their scabs, supported the doubt—not a single indication of the disease developed on the vigorously growing sour-orange seedlings used in the tests. The inoculations were repeated three times, during three differ-

[2] Experiments on the decay of Florida oranges. U S Dept. Agr., Bu. Pl Ind Cir. 124: 17–28. 1913.

[3] Fawcett, H. S. Citrus Scab Fla. Agr. Exp. Sta Bul. 109: 51–60. 1912.

[4] Scribner, F. L. Notes on the orange leaf scab. Bul. Torr. Bot. Club **13**: 181–183. 1886.

[5] Underwood, L. M. Diseases of the orange in Florida. Journ. Mycol. 7: 34. 1891.

ent growth periods. The same results were obtained on young budded grapefruit trees on sour stock.

In the spring of 1914 a number of sour-orange seedlings which were about two years old, were cut back to stubs about a meter high. Three of them were carefully scrubbed with a 1 to 1000 mercuric-bichloride solution and immediately inclosed in cheese cloth stretched around four stakes driven in the ground. The tops and bottoms were also closed with cheese cloth. Two unsterilized trees were inclosed with cheese cloth at the same time. Other trees were only partly inclosed.

After the completion of the spring growth (the last of April) the leaves were counted on all trees under experimentation. The percentage of scabby leaves on the inclosed trees was practically as great as that on those in the open, and the trees sterilized before enclosing were almost as scabby as the others, about 4 per cent of the leaves being affected.

The cultural tests made from numerous early-stage scabs of both fruit and leaves only rarely gave Cladosporium, and more frequently other fungi. In mid- and late summer the scabs having Cladosporium present could usually be selected with the unaided eye because the dark-fruiting fungus was readily seen. This fungus generally could not be obtained from the scabby warts where its spore masses were not evident at that time.

After considering the various possibilities that may be involved in the origin and development of sour scab, its cause becomes obscured rather than clarified, although interesting glimpses are seen of processes that may give some additional clues regarding its cause. The tangible evidence in support of the idea universally held, that *Cladosporium Citri* causes sour scab, is slight and inconclusive. In fact, the evidence to the contrary is even stronger. It all tends to show that the question needs more extended critical study before conclusions can be drawn regarding the cause of this disease.

The results of the spraying experiments to be detailed below, however, apparently give support to the theory that this disease is due to some pathogenic organism, although it is also possible that the sprays may have some other than germicidal action in the prevention of sour scab.

THE PREVENTION OF SOUR SCAB BY SPRAYING

During the past three seasons experiments in the prevention of the sour scab disease have been carried on in cooperation with growers in different sections of the state of Florida. The results show that preventive measures pay even under the most trying conditions.

In 1913 bordeaux mixture made according to the formula 3-3-50, and lime-sulphur solution, testing 32°B., diluted 1 to 40, were used on

separate rows. The number of applications for the season varied from three to six. The early stage of scab was noticeable on the new growth when the first application was made during the first week in March. In another grove the first application was made on April 20. In the grove first sprayed early in March both bordeaux and lime-sulphur prevented the development of much scab when compared with the unsprayed rows. But where the first spraying was done on April 20 the sprayed trees had practically as much scab as the checks.

In 1914 the first application of spray was made on February 26 in one case, and in another on March 6. Some scab was noticed on the new growth in both groves when this application was made. The result was much like that for 1913, in that the check rows had appreciably more scab than the sprayed ones. But all sprayed rows also had scab. Those sprayed with bordeaux mixture had somewhat less than those sprayed with lime-sulphur solution.

In 1915 the first application was made on February 25 to 27 in one grove, and on March 8 in another. Some scab was noticed on the earliest new growth in both groves. The second applications were made eight days after the first and later ones at intervals of eight to twenty-one days.

The results were surprising in that the new growth, developing during the frequent early sprayings, was practically as scabby on the sprayed as on the unsprayed trees, except on the few scattered trees which had made but slight growth. The fruit, however, showed marked differences between the sprayed and the unsprayed rows, as well as between those sprayed with bordeaux mixture and those receiving lime-sulphur solution, the former giving better results as far as scab is concerned.

In the case of a grove near Orlando where the disease had been uncommonly bad during at least three years, and where enough fruit occurs to permit a fair comparison, the results were as follows: On the rows sprayed with bordeaux mixture, 60 per cent of the fruit was scabless, and on the rows sprayed with lime-sulphur only about 32 per cent was free of scab, while on the unsprayed, or check rows from 95 to 100 per cent of the fruit was scabby.

In another grove under experiment near Bradentown in 1915, the results were even more definite and better, in spite of the fact that only a few scattered trees in each row bore fruit of any consequence: usually two to four trees per row bearing from two to six boxes each. In this case bordeaux mixture was used on one row, lime-sulphur solution on four rows and soluble sulphur on four rows. Three rows were left as checks, unsprayed.

The percentages of scabby and scabless fruit were obtained by counting and arranging in two classes, all fruit on five unsprayed trees out of sixty-

three, on two of the twenty-one on which bordeaux mixture was used, on four of the eighty-four trees sprayed with lime-sulphur solution and on four of the eighty-four trees sprayed with soluble sulphur compound. The unsprayed trees averaged only 17 per cent of scabless fruit, while those sprayed with bordeaux had an average of 93.5 per cent in that class. The trees sprayed with lime-sulphur solution and soluble sulphur compound gave practically the same results, both having over 50 per cent of scabless fruit.

For this season, then, the results were not only below those of the two previous seasons in the protection afforded the fruit, but the first spring growth seemed to have developed scab this season irrespective of spraying. Yet, in spite of the lesser degrees of protection afforded by the sprays this year, the difference between the sprayed and unsprayed trees was still great enough to make spraying a good investment even if lime-sulphur alone were used.

THE RESULTS AND CONCLUSIONS WARRANTED BY THESE SPRAYING EXPERIMENTS

In determining the practicability of spraying to protect the young fruit from scab, it is better to base the conclusions on results obtained under adverse conditions than on those from the more favorable seasons, because in that way the efficacy of a method will more likely be under- than over-estimated. This may be illustrated by citing the results secured in 1913 and 1914, as compared with those of 1915. Although scab was abundant during those two seasons, the preventive methods yielded a much higher percentage of scabless fruit than in 1915. A general summary of the two years shows about 75 per cent scab control for bordeaux mixture and about 60 per cent control for lime-sulphur solution for both foliage and fruit, while the check or unsprayed rows showed scab on about 60 per cent of both fruit and leaves. This comparison shows beyond a doubt that general conclusions are not admissible from less than three years tests, and that even three years is a short time for anything but tentative conclusions. The inferences to be drawn from results secured in 1915 are that sometimes it may be impractical to prevent sour scab from appearing on foliage, either with bordeaux mixture or with lime-sulphur solution; while for the fruit the bordeaux gave even a higher percentage of protection than in former seasons, and lime-sulphur fell lower in its efficiency by about 18 per cent, than it had during the two preceding years. For the fruit the average for the three years shows bordeaux to give 79 per cent, and lime-sulphur 45 per cent protection from scab.

The experiments of 1915 show that even under severe conditions it is

needless to spray more than four times and that for the protection of the fruit alone three applications suffice. A portion of the grove near Orlando was sprayed nine times, while in that near Bradentown the rows sprayed only four times were as well protected as those sprayed six times. The same thing is also shown in comparing the results on rows 18 to 22 of the grove near Orlando which were sprayed only six times, for they have as much scabless fruit as the rows sprayed eight or nine times.

These results also show that ordinarily it is a waste of time and material to spray after the middle of May for scab. In the grove near Bradentown where only four applications were given to some rows, the last spraying was done on April 16. The omission of the late-May application from certain rows in the grove near Orlando, did not reduce the percentage of scabless fruits for those rows.

A TENTATIVE SPRAYING SCHEDULE FOR SCAB

If it is desired to prevent scab on the new growth or foliage, the first application should probably be made a little while before growth starts in spring and should cover all the old foliage. If only the fruit is to be protected from scab the first application of spray should be made when the bloom has reached its height or just after the earliest blossoms drop, and should be given chiefly to the new growth. This treatment also serves as the second application for the protection of the new growth. The second application for the fruit should be made about a week or ten days after the first, and be confined mainly to the new growth and fruit. The third and last spraying for the fruit or the fourth for the new growth should be made in about two to three weeks after the second fruit application.

Both lime-sulphur solution and bordeaux mixture have certain defects, when used separately for the prevention of scab, that it would be desirable to eliminate if possible. Bordeaux sticks rather too tenaciously to be used more than once or twice in a season; and the application made during the height of the bloom sometimes kills back some of the youngest growth. If the mixture is applied during the emergence of the new growth, nearly all of it may be killed back.

Even though great care is taken to always hold the spray nozzles directed downward and chief attention is given to the new growth and fruit, an appreciable increase of scale insects usually follows the *repeated* use of bordeaux mixture, though it is generally not necessary to spray for scale until two to five months after the last treatment with bordeaux mixture. A much higher percentage of the bordeaux-sprayed fruit may become russet. In fact, in 1915 only the trees sprayed with bordeaux mixture bore russet fruit.

Lime-sulphur solution, testing 32°B., diluted 1 to 40, as used in the above experiments, gives a lower degree of protection from scab; however, it does not injure the tenderest growth, and at the same time kills rust mites in all stages, as well as the creeping forms of scale insects.

From the results cited here as well as from others not mentioned, the writer suggests the use of lime-sulphur testing 32°B. (or its equivalent) made up 1 to 30, just before growth starts in spring, if it is desired to protect the earliest new growth. Bordeaux mixture made up according to the formula 3-3-50, is to be applied during the height or middle of the blooming period, and either bordeaux or lime-sulphur solution, 1 to 40, should be used a week or ten days later. A final spraying, of lime-sulphur solution (1 to 40), should be made in two to three weeks.

This schedule obviates the most undesirable features encountered when using either bordeaux or lime-sulphur alone, and at the same time will give a high degree of protection from sour scab, and also keep down the mites and scales to a minimum.

THE COST AND RETURNS FROM SPRAYING

Using the results from the tests of 1915, it is readily seen that the net returns from spraying for sour scab depends not only upon the efficiency of the spraying and the material used, but also upon the amount of fruit the trees bear. Neither of the groves used for experimentation had a full crop; in fact one of them had fruit of consequence only on scattered trees. Thus the net profit becomes much reduced. In the best portion of the other grove the trees had about a half crop, or four boxes per tree. Here the net returns from spraying are more worth while even for a season in which prevention was difficult.

In order to get figures that will apply to an ordinary crop-year in a grapefruit grove, it is best to use only the counted sprayed and unsprayed trees in the two experiments as a basis for general deductions.

For a generalized view that aids in drawing conclusions regarding the cost and net returns involved in spraying for scab, the following condensed table is useful.

It will be seen from table 1 that on the twenty-four sprayed trees, from which counts were made, 51 per cent of the fruit was scabby while on the eight unsprayed trees counted, 95 per cent of the fruit was scabby. On the basis of trees set 25 by 25 feet and yielding four boxes of fruit per tree and assuming that scabless fruit sold at $1 per box and scabby fruit at $.50 per box, there would be secured from an orchard, as severely affected as those used in the experiments, a gross income of $205.50 per acre.

On the same basis an unsprayed grove would yield only $144.90. After deducting $17.60 per acre for spraying there would be left a net profit for spraying of $43 per acre. This additional profit per acre would often make the difference between profit and loss and would therefore be a great stabilizer for the citrus business. Figured on the basis of an investment to the amount of the cost of spraying, it shows the handsome profit of 244 per cent. The conclusion is therefore obvious that it pays to spray for scab.

TABLE I

Generalized summary of spraying experiments for control of citrus scab

Orlando experiment

MATERIAL USED	NUMBER OF TREES COUNTED	TOTAL NUMBER OF FRUITS	SCABLESS FRUITS		SCABBY FRUIT	
			Number	Percentage	Number	Percentage
Bordeaux	5	1281	887	69⅓	394	30⅔
Check	4	1262	6	½	1256	99½
Lime-sulphur	9	2371	542	22⅕	1829	77⅕
Bradentown experiment						
Bordeaux	2	628	587	93½	41	6½
Check	4	597	88	14½	509	85½
Lime-sulphur	4	1024	527	51½	497	48½
Soluble sulphur	4	843	454	53½	389	46½

THE CONTROL OF SCAB BY PRUNING

No first-hand or independent experiments have been conducted in endeavor to protect the new growth from scab by pruning out the old growth that is scabby, but a number of such experiments by growers in different parts of the state have been closely followed during the past three seasons. Some of these experiments have been on a large scale and have been executed with care and therefore give some notion of the feasibility of the method when applied in localities where the disease is prevalent. But of course the results do not apply to sections where scab occurs only mildly, and on scattered trees.

Without going into details it may be said that the results do not warrant making it a general method of combating the disease in bearing groves, in places where it usually occurs in abundance. As a matter of fact no improvement is usually noted from such pruning except when the disease occurs only on a few isolated or scattered trees. In several instances of wholesale pruning of badly scabbed bearing groves, the results have not only been of questionable value, but the subsequent new growth seemed to develop as much scab as that on the unpruned trees.

SUMMARY

1. Sour scab of citrus causes a great financial loss in the growing of grapefruit in Florida, Cuba and the Isle of Pines.

2. The disease develops most destructively in seasons and localities having abundant moisture in both air and soil during the development of the first spring growth (may not apply to the June bloom).

3. Trees starting growth latest in spring are least subject to sour scab; therefore, the selection of buds from such individual trees chosen from among the best commercial varieties of grapefruit, may also prove of value in reducing the loss from this trouble.

4. Grapefruit trees budded on rough-lemon stock, are more susceptible than those on sour-orange stock.

5. The causes of the disease have not yet been satisfactorily determined. *Cladosporum Citri*, to which the disease is usually attributed, is at most, only partially responsible.

6. The long-continued presence of liquid water on rapidly growing leaves and shoots, and on very young grapefruits, in connection with excessive hydrostatic pressures often developing incident to strong growth, and probably the accumulation of injurious volatile products in water films on such growing leaves and fruits, appear to have a causal relation to the development of sour scab.

7. Experiments carried on during three years in cooperation with growers have shown that it is both practical and highly remunerative to spray grapefruit trees in susceptible localities three or four times with bordeaux mixture and lime-sulphur solution. One application of bordeaux mixture during the height of the blooming period, followed in a week or ten days by one of lime-sulphur solution, and by a second one of lime-sulphur solution in from two to three weeks after the second spraying, is suggested as the best schedule for the protection of the fruit.

8. The method of pruning out of scabby growth from severely affected groves is impractical and sometimes even injurious to the trees.

APOPKA, FLORIDA

CUCUMBER MOSAIC DISEASE

W. W. GILBERT

WITH PLATE V

A new mosaic disease of the cucumber, commonly called white pickle, has made its appearance during the past few years in greenhouse and field in various sections of the country where cucumbers are grown commercially.

Occasional specimens of this trouble have been received by the U. S. Department of Agriculture from different greenhouses during the past seven or eight years. Selby reported the occurrence of a mosaic disease of cucumbers in the Ashtabula, Ohio, greenhouses as early as 1902 and Stone reported a similar disease in Massachusetts greenhouses in 1909. Both state that there was no evidence of contagion so that it is probable that another type of mosaic possibly due to malnutrition, was referred to. At the present time the mosaic disease is known to occur in greenhouses in Minnesota, Michigan, New York, Pennsylvania, Illinois, Indiana, Ohio and Louisiana.

The occurrence of the disease in field-grown cucumbers seems not to have been reported and has not been generally known until within the last two years. Recent conversations with pickle growers of the Middle West and with others make it appear reasonably certain that the trouble has been present in the field for at least ten years. It is now known to occur in the field rather generally in Wisconsin, Michigan, and Indiana, and has been found also in Ohio, Iowa, Illinois, Vermont, New York, Minnesota, Massachusetts, and Virginia, and in Ontario, Canada.

In 1914 Mr. S. P. Doolittle, of the Michigan Agricultural Experiment Station, and Mr. I. C. Jagger, of Cornell University, began work on this disease independently. Mr. Jagger has studied the trouble as it occurs in the greenhouses of Irondequoit, New York, and vicinity, and all his experiments have been carried on in the greenhouse. Mr. Doolittle's work has been with cucumbers grown in the field for pickling purposes. In 1914 he was located at Hamilton, Michigan, where the disease had been serious the previous season. In 1915 the U. S. Department of Agriculture inaugurated a cucumber disease project in cooperation with the Michigan Experiment Station and others, in charge of the writer and subsequent work by Mr. Doolittle on cucumber mosaic disease has been done.

under the joint direction of Dr. E. A. Bessey of the Michigan Agricultural Experiment Station and the writer. The past season some work was continued at Hamilton but the major part of the experiments was performed at Big Rapids, Michigan, where a cucumber disease laboratory was located.

The results secured by Mr. Doolittle and Mr. Jagger were found to agree in so many particulars that it was thought advisable to publish thus simultaneously this preliminary statement of progress to date.

BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C

EXPLANATION OF PLATE V

FIG. 1. Cucumber plant in a field at Holland, Michigan, badly affected with mosaic disease. Lead pencil shows relative size of plant. At *(a)* note runners very much dwarfed with very small wrinkled leaves, at *(b)* a very warty fruit. Photograph made August 19, 1915. W. W. G.

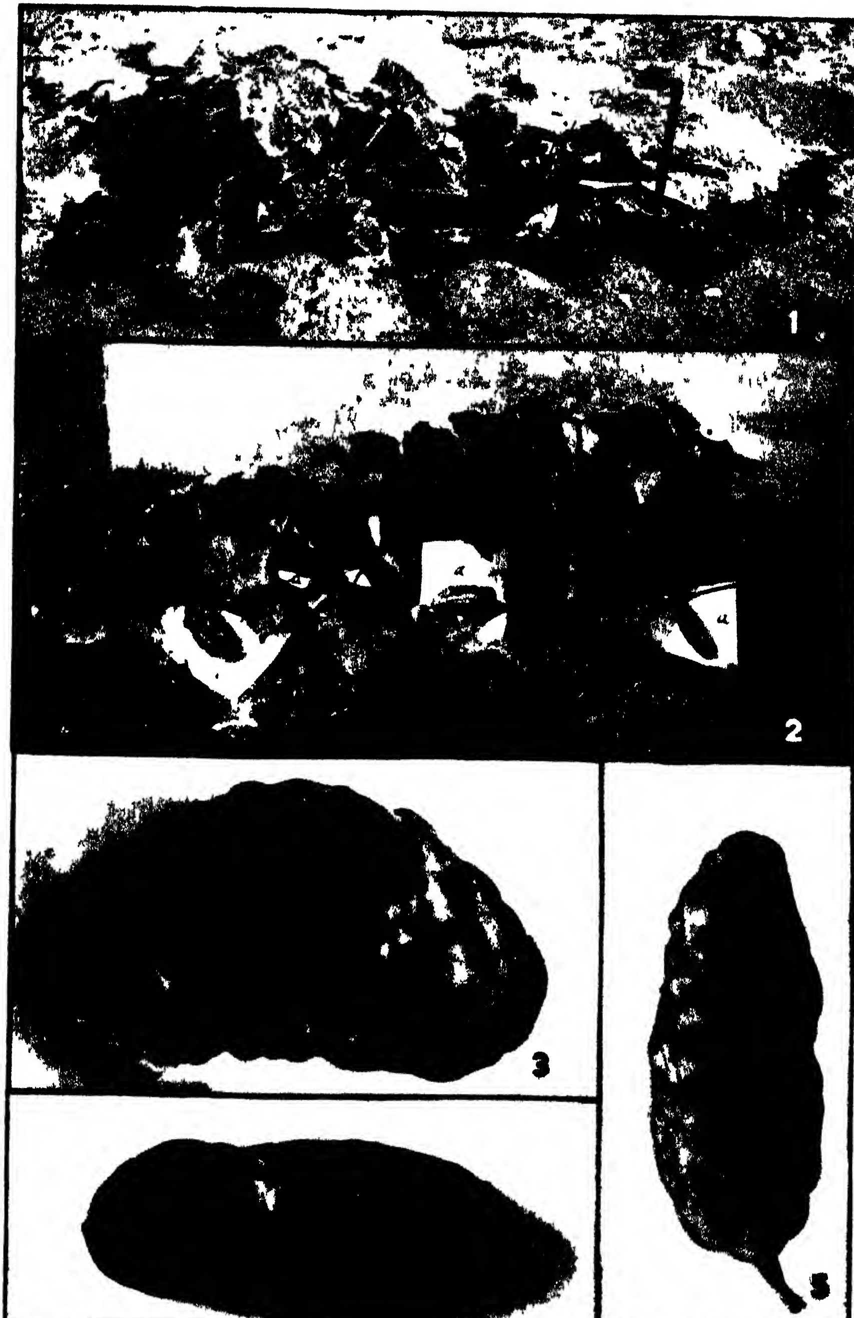
FIG. 2. Cucumber mosaic disease produced at Big Rapids, Michigan, by S. P. Doolittle, by transferring to a healthy plant aphids from a mosaic diseased plant. Note at *(a)* the warty and mottled fruits, the principal symptoms showing when this photograph was taken. Photograph made September 1, 1912. W. W. G.

FIGS. 3 and 4. Fruits from cucumber plants at Holland, Michigan, affected with mosaic disease.

FIG. 3. Misshapen fruit with large and small warts of dark green color, remainder of pickle mottled light and dark green.

FIG. 4. Small pickle, yellowish white except for the large dark green wart at one end and a few scattered spots of green. Photograph made August 22, 1915. Crandall.

FIG. 5. Small mottled and warty pickle from mosaic diseased vine in the field at Irondequoit, N. Y. Photograph made by I. C. Jagger.



CUCUMBER MOSAIC

jected into three plants; distilled water was injected into three plants. In nine days one plant receiving sterile juice developed mosaic but all others were healthy at the end of five weeks. When inoculated the plants were fourteen weeks old and the stems had become so woody that the liquid was with difficulty forced into them. This may account for the poor results.

August 31. Three to twenty aphids (*Aphis gossypii* Glover) were transferred with a camel's hair brush from mosaic diseased plants to the following eleven healthy plants: eight small potted plants with two or three leaves each; one bearing plant six weeks old; one plant three months old, and one plant five months old. These plants were enclosed in cheesecloth cages. In four days a few plants showed mosaic symptoms and in seven days all were diseased except one of the potted plants, while two nearby bearing plants, receiving no aphids were healthy and of eight nearby potted plants receiving no aphids only one was diseased and this was probably due to the escape of an aphid.

October 1. A few aphids were transferred from mosaic diseased plants to seven small plants in pots and covered with a screen. In two weeks five plants were affected with mosaic while seven nearby plants receiving no aphids were all healthy.

October 9. Fifteen to one hundred aphids from healthy plants were transferred to each of seven small potted plants, and six to fifteen aphids from mosaic plants to seven similar plants. The two lots were covered with separate cages. In eleven days five plants receiving aphids from diseased plants showed mosaic while all receiving aphids from healthy plants were free from disease.

November 12. Yellow leaves of a plant that had recently developed mosaic disease were crushed in the hands. Eleven small potted plants, 3 to 12 inches high, and three large bearing plants were inoculated by rubbing a small area of both the upper and lower surface of two or three leaves on each plant with the crushed diseased leaves. Rubbing was sufficiently vigorous to break the epidermis and leave small pieces of diseased tissue clinging to the leaves. The leaves of a second lot of fourteen similar plants were inoculated in the same mannor with dwarfed, much mottled leaves from a plant affected with mosaic for several weeks. The leaves of a third lot of fourteen similar plants were rubbed with clean hands as checks. At the end of fourteen days three bearing plants and two potted plants of lot one showed the first symptoms of mosaic, two potted plants of lot two showed questionable early symptoms of mosaic, and the fourteen plants of lot three were all healthy. At the end of nineteen days, three bearing plants and four potted plants of lot one showed mosaic, one bearing plant and three potted plants of lot two showed mo-

saic, and the fourteen plants of lot three were all healthy. Several plants in lots one and two, not included among those reported as diseased, showed questionable early symptoms of mosaic.

September 12. Six cucumber plants, growing in a greenhouse soil bench, in which all plants were healthy, were trained so that the foliage was in contact with the foliage of mosaic diseased plants in the opposite bench. The foliage was handled very little and with great care. In six to twenty-seven days four plants developed mosaic, while the other two were still healthy when removed at the end of two months. Eight similar plants alternately located and not in contact with diseased plants were healthy at the end of two months.

Eight plants were at the same time transplanted into the same bench with the mosaic diseased plants at distances of 5 to 10 inches from them, so that roots of healthy and diseased plants undoubtedly soon became interlaced. The foliage was trained so that it never came in contact with foliage of diseased plants. At the end of three months all eight plants were healthy.

December 1. Five small potted cucumber plants and two large bearing plants were inoculated by pinching. Three or four leaves on each plant were given a single pinch with thumb and finger, which had, immediately preceding each pinch, given a single pinch to a mosaic diseased cucumber leaf. Considerable pressure was applied in pinching, but care was taken to give no rubbing motion, which would tend to break the epidermis of the plants. No apparent juice or tissue was transferred but undoubtedly there was a transfer of many plant hairs. At the end of twenty-three days five potted plants and one large plant showed mosaic, while one large plant was healthy. Seven comparable check plants were all healthy.

December 1. Two plants of crookneck summer squash, two of garden or pie pumpkin, three plants of two varieties of gourd, and three plants of cucumber were inoculated by rubbing the leaves with crushed leaves of mosaic diseased cucumbers, as in preceding experiments. Ten exactly comparable plants were similarly rubbed with leaves of healthy cucumber plants as checks. All plants were small, and bore three to seven leaves. At the end of fourteen days all inoculated plants showed early symptoms of mosaic. At the end of thirty-four days all check plants were healthy; the three inoculated cucumbers had developed mosaic foliage, wilted and died; the two crookneck squashes had developed several dwarfed, mottled leaves with much shortened internodes, and one plant bore a fruit 2 inches long which was mottled and abnormally warted; the three gourds and two pie pumpkins had all developed dwarfed, mottled leaves with shortened internodes. Mosaic diseased gourds, pumpkins and squashes had showed no wilting and death of foliage and grow-

ing tips, such as usually occurs in cucumbers under such greenhouse conditions.

A mosaic disease, which appears to be identical with the one obtained by inoculation, has been observed during two seasons to be of common occurrence in fields of crookneck summer squash at Irondequoit, N. Y.

December 18. Potted cucumber plants, bearing three to seven leaves each, were inoculated by rubbing leaves with crushed leaves of mosaic diseased squashes and gourds, infected in the preceding experiment. Three plants were inoculated by using leaves from crookneck summer squash, three, by using leaves from one variety of gourd, and three by using leaves from the second variety of gourd. Two plants were rubbed with crushed leaves from each of three respectively healthy plants as checks. At the end of 16 days mosaic symptoms were evident. At the end of 28 days the six check plants were healthy; two plants inoculated from crookneck squash, two plants inoculated from one variety of gourd, and three plants inoculated from the second variety of gourd had developed mosaic foliage, wilted and died.

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FURTHER STUDIES IN THE RÔLE OF INSECTS IN THE DISSEMINATION OF FIRE BLIGHT BACTERIA

V. B. STEWART AND M. D. LEONARD

During the summer of 1914 experiments were conducted by the writers to determine the rôle of sucking insects in the dissemination of fire blight bacteria. In the experiments only insects were used which puncture the tissues of the plants with the bristles of their beaks. In discussing the results of the experiments which are recorded in a previous paper[1] the writers make the following statement: "Certain species of flies are attracted in considerable numbers to the gummy exudations of blighted trees and they, no doubt, carry the bacteria from place to place. It is possible that these flies may produce fire blight inoculations by injuring the tissue with their claws. However, no experimental data are at hand to substantiate this point."

During the summer of 1915 experiments were conducted with two species of flies which were abundant on apple and pear nursery stock in order to determine their ability to produce blight infections. Other experiments were performed also to determine the importance of several sucking insects as fire blight disseminators.

The experiments included the following species: *Pollenia rudis* Fabricius, *Empoasca mali* Le Baron, *Psylla pyricola* Forster, *Plagiognathus politus* Uhler and *Sapromyza bispina* Loew.

Young apple and pear seedlings with succulent shoots were selected and in caging the insects over the trees two types of cages were used. Where several seedlings were included in the experiment, the trees were covered with large cages in the shape of a triangular prism with the dimensions 3 by 1½ by 1½ feet. The cages were made of wire cloth twelve meshes to the inch and covered with cheesecloth. In some cases single trees were covered with small cylindrical cages about 15 inches in height and 4 inches in diameter, made of wire cloth and covered with cheesecloth. In each case the insects were transferred to the cages which were then inverted over the trees, care being taken not to injure the shoots during the operation.

[1] Stewart, V. B. and Leonard, M. D. The rôle of sucking insects in the dissemination of fire blight bacteria. Phytopath. 5: 117–123. 1915.

A four-days-old agar culture of *Bacillus amylovorus* (Burr.) Trev. was used in all the experiments, the culture being smeared on the shoots with a camel's hair brush.

EXPERIMENT 1

Pollenia rudis Fabricius. This is the common cluster fly which is frequently found in houses especially in the spring and autumn. This species was found very commonly during the summer of 1915 on apple, pear, quince and peach nursery stock.

The experiment was set up July 12 and final results recorded August 5. A large cage was placed over six succulent apple seedlings two of which had been smeared with the agar culture of *Bacillus amylovorus*. About thirty cluster flies were released inside the cage. On July 27 the shoots of one of the trees which had been smeared with the culture were blighted. On August 5 the blight was slightly more advanced in the infected seedling but none of the other trees in the cage had become diseased.

In a similar cage about twenty-four cluster flies were released. No culture was smeared on the shoots. On August 5 no blight had appeared in this cage.

It is believed that the infections which occurred on the one tree smeared with the culture, were due to the presence of aphids on the shoots. When the cage was removed a careful examination showed the presence of several aphids on the seedling which apparently were overlooked at the time the experiment was set up. No aphids were found on the other trees and the fact that this was the only tree which blighted, seems to indicate that the aphids rather than the flies, were responsible for the infections. The results of experiment 2 substantiate this opinion.

EXPERIMENT 2

Pollenia rudis Fabricius. On July 27 eleven flies were allowed to walk over an agar culture of *Bacillus amylovorus* and were then placed in a large cage covering six seedling apple trees. Six flies which had not walked over the culture of the blight organism also were released inside the cage. The tips of two of the trees were smeared with a culture of the blight organism. On August 17 none of the trees had blighted.

A small cage containing ten flies was placed over an apple seedling. No culture was smeared on the shoots. The tips of two other seedlings were smeared with the blight culture and each tree covered with a small cage. The flies were excluded. On August 17 none of the shoots had blighted.

EXPERIMENT 3

Empoasca mali Le Baron. The experiment was set up July 12 and final results taken July 27. A cage was placed over six apple seedlings. The shoots of three of the seedlings were smeared with the agar culture of *Bacillus amylovorus*. About twenty-four apple leaf-hoppers were released within the cage. On July 27 two of the trees which had been smeared with the culture were badly blighted. No infections appeared on the other four trees.

A small cage containing eight leaf-hoppers was placed over an apple seedling. No culture was smeared on the shoots. On July 27 the check tree showed no blight.

EXPERIMENT 4

Empoasca mali Le Baron. On July 27 thirty adult leaf-hoppers were released within a cage which covered five seedlings, two of which were smeared with the agar culture of *Bacillus amylovorus*. On August 17, two of the shoots of one tree on which the culture had been placed, and two shoots of a tree not smeared with the culture were badly blighted. On another tree which had not been smeared with the culture there were fire blight lesions on the mid-rib of two leaves but the infections did not extend down the petiole to the twig. Many of the leaves were considerably curled by the feeding of the leaf-hoppers

Six seedlings confined under a large cage were smeared with the culture of *Bacillus amylovorus* but the leaf-hoppers were excluded. On August 17 one shoot showed a slight infection of fire blight and on careful examination two leaf-hoppers were found on the leaves. Since it was impossible for the leaf-hoppers to have entered through the cheesecloth, apparently a too hasty search failed to reveal their presence before the cage was placed over the trees. A few of the trees in the experimental block were found previously to be infested with apple leaf-hoppers and this necessitated their removal before each of the experiments was set up.

Seven leaf-hoppers were placed in a small cage which was inverted over a single apple seedling. The culture was excluded. On August 17 nothing but leaf-hopper injury was apparent on the seedling.

EXPERIMENT 5

Psylla pyricola Forster. This is the common pear psylla. The adults and nymphs have been found commonly throughout the summer months on pear nursery stock in the vicinity of Rochester, New York.

On July 27 the terminal shoots of one of six pear seedlings were smeared with the agar culture of *Bacillus amylovorus*. Fifteen adult psyllas were

caged over these seedlings by means of a large cage. Ten adu t psyllas which were first allowed to walk over a blight culture were also released under the cage. When examined for the last time, August 17, all the trees were free from blight.

On July 27 a pear seedling was covered with a small cage containing twelve psyllas. No culture was placed on the shoots. None of the shoots blighted.

On July 27 the terminal shoots of three pear seedlings were smeared with the agar culture of *Bacillus amylovorus* and a small cage placed over each tree. The psyllas were excluded. When final observations were made on August 17 none of the seedlings was diseased.

EXPERIMENT 6

Psylla pyricola Forster. On August 5, fifty adult psyllas were confined in a cage which was placed over six pear seedlings. The tender shoots of two of the seedlings had been previously smeared with the agar culture of *Bacillus amylovorus*. When examined for the last time three weeks later none of the shoots had blighted.

The shoots of five pear seedlings were smeared with the agar culture and covered with a large cage. The psyllas were excluded. All of the trees remained healthy. On August 5 twelve adult psyllas were confined within a small cage over one pear seedling but the blight culture was excluded. When examined August 25, no infections were apparent.

From observations made in badly blighted pear orchards where the psyllas were abundant, it seemed highly probable that these insects were responsible for many twig blight infections. The negative results of these experiments may possibly be due to the relatively few insects used in each cage, as compared to conditions in an orchard badly infested by psyllas. On the other hand, the shoots of the trees were tender and succulent and conditions were ideal for infections to occur, had any of the blight bacteria been deposited in the feeding punctures made by the psyllas.

EXPERIMENT 7

Plagiognathus politus Uhler. On July 21, thirty-five adults of this Capsid were allowed to walk over the agar culture of *Bacillus amylovorus* and then released under a large cage covering six apple seedlings. When final observations were made on August 5, five of the six seedlings were badly blighted and the other seedling showed a single infection.

On July 21, the shoots of three apple seedlings were smeared with the agar culture and each covered with a small cage. The bugs were excluded.

The trees remained healthy. At the same time eight adult bugs were liberated within a small cage covering an apple seedling but the culture was excluded. No infections occurred.

EXPERIMENT 8

Sapromyza bispina Loew. On July 21 a large cage containing twelve flies was placed over six apple seedlings. The shoots of two seedlings had been smeared with the agar culture of *Bacillus amylovorus.* When final observations were made August 5, none of the trees had blighted.

A small cage containing ten flies was placed over one apple seedling; the culture was excluded. No infections occurred.

Three apple seedlings were smeared with the agar culture, and each tree covered with a small cage but the flies were excluded. All of the trees remained healthy.

The results of experiments previously reported[2] in conjunction with those herein recorded include data on practically all the insects which might be important in producing fire blight infections in the nurseries of New York State. The false tarnished plant bug (*Lygus invitus* Say) and the apple red bugs (*Heterocordylus malinus* Reuter) and (*Lygidea mendax* Reuter) are occasionally found on nursery stock but they are undoubtedly of more importance in spreading fruit blight in orchard trees. Owing to the scarcity of these species in the nursery they were not included in the experimental work.

As seen from the results of experiments 1, 2 and 8, apparently the various species of flies are not active agents in increasing the number of twig blight infections. Although they feed in great numbers on the blight exudations and may carry the organism to other shoots, the method of feeding of the flies renders it improbable that the blight bacteria may become established in the tissues of the shoot. Repeated experiments have shown that the bacteria gain entrance to the tissue of the twigs only through injuries. It is not believed that such insects as flies are capable of producing wounds which afford an entrance of the blight organism into the twigs.

The injuries produced by certain sucking insects, such as the tarnished plant-bug (*Lygus pratensis* Linn.), often exude slightly and the possibility has been suggested that the blight ooze is carried to these insect punctures by flies which feed on the exudations from the wounds. Some of the blight bacteria on the fly's body being left in the exudation, later produce an infection by gaining an entrance to the tissue through the insect puncture. Infections might occur in this manner but the importance of the

[2] Ibid.

method may be over-estimated. Several factors are involved: hot, sunshiny weather rapidly dries out the exudation of the insect puncture, making it less attractive to the flies. Also the same conditions of weather affect the blight ooze laden with bacteria which is carried by the flies. The gummy substance soon becomes dry and hard thus reducing the chances of many bacteria being liberated in the exudation of the insect puncture. Also the longevity of the blight organism is relatively short when exposed to the direct rays of the sun. On the other hand, when the blight is very prevalent and there are also numerous flies and sucking insects present, a few infections may occur in the manner suggested above. It is believed that the flies are most important in carrying the causal organism to blossoms and occasionally to wounds as in such cases as have been previously reported by Stewart[3] where many injuries to the trees were produced by hail stones and the flies carried the blight bacteria to these wounds.

In a recent article by A. C. Burrill[4] are recorded the results of experiments conducted to determine the importance of the grain aphis (*Siphocoryne avenæ*) and the apple leaf-hopper (*Empoasca mali*) in the dissemination of blight bacteria in Wisconsin. Burrill is of the opinion that leaf hoppers are the most active agents in disseminating the blight bacteria in Wisconsin. He found them very prevalent throughout the entire season and believes that for Wisconsin at least, they are of greater importance than such species as the tarnished plant bug. In Wisconsin the tarnished plant bug does not occur in abundance on nursery stock until August and Burrill does not correlate this insect with blight infections which appear earlier in the season. Evidently the prevalence of the tarnished plant-bug for any definite time, varies with the locality. Haseman[5] reports this insect as being most destructive in Missouri early in the season. Stewart[6] reports an outbreak of fire blight in two-years-old Kieffer pear trees, which occurred very early in the season, soon after growth started. This epiphytotic of the disease was attributed to the presence of tarnished plant-bugs which were exceedingly prevalent on the pear stock at that time.

From observations made throughout several seasons the writers are of the opinion that all of the sucking bugs found in the nursery are of more

[3] Stewart, V. B Notes on the fire blight disease. Fire blight favored by a hail storm. Phytopath. 6: 333 334 1916.

[4] Burrill, A. C. Insect control important in checking fire blight. Phytopath. 5: 343-347. 1915.

[5] Haseman, L. Peach "stop-back" and tarnished plant bug. Jour Econ. Ent. 6: 238. 1913.

[6] Stewart, V. B. The importance of the tarnished plant bug in the dissemination of fire blight in nursery stock. Phytopath. 3: 273-276. 1913.

or less importance in producing fire blight infections and must be considered *tout ensemble*. The relative importance of each species is difficult to determine. By virtue of their method of feeding and prevalence during each season, certain species are undoubtedly more destructive than others. On the other hand, under special conditions when a certain species is found in large numbers it may become of considerable importance. Usually the tarnished plant-bug is more injurious than the leaf-hopper from the fact that the greater percentage of leaf-hopper punctures occur in the leaf tissue. Relatively few fire blight infections which originate in the leaf ever extend down the petiole to the twig. For this reason although the leaf-hoppers are very abundant, they may be of less importance in the nursery than insects which feed only on the tender tips of the twigs.

During the summer of 1915 Heald[7] observed in the state of Washington numerous leaf infections caused by *Bacillus amylovorus* on apple and pear trees. He is inclined to believe that the blight bacteria gained entrance to the leaf tissue through the water pores. The writers are of the opinion that for New York State at least, few if any blight infections occur through the water pores of the leaf, an injury of the tissue being necessary for the bacteria to produce infection.

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[7] Heald, F. D. Preliminary note on leaf invasions by *Bacillus amylovorus*. Washington Agr. Exp. Sta. Bul. 125: 3-7. 1915.

NOTE ON APPLE ROOT-ROT IN VIRGINIA

C. H. Crabill

With One Figure in the Text

Root-rot of apples in Virginia is most prevalent in the Shenandoah Valley and in the Piedmont sections. It is very destructive even where the best methods of sanitation and management are practiced. Little is known about it and no attempts have yet been made to control it. Trees affected with root-rot may die at any age but most of those lost are ten to fifteen years old. Young trees set where rotted trees were removed usually die in two to eight years.

The root-rot has been previously described,[1] but the symptoms will be again presented here. The first indication of the disease is a cessation of growth, followed by a loss of some of the foliage then by the death of a portion of the top of the tree. The roots at this time are nearly all dead, punky and brittle and filled with fine white fungus mycelium. The tree can be pushed over readily in nearly every case. The roots break off short near the stump. Deep-lying roots are usually first affected. Growth is then thrown into the more superficial ones, which support the tree for a time. In a short time these roots also die and decay. The wood above the affected roots dies, shrinks and turns brown, due to obstruction of the water supply from the soil.

Observations and reports from orchardists have brought to light the following facts: (1) Root-rot is more prevalent on new ground, especially where the soil contains decaying wood, than on ground which has been cultivated for some years before the orchard was set; (2) root-rot is present on a wide variety of soils and on both steep slopes and low bottom lands; (3) in many orchards several adjoining trees in a group have contracted the disease at about the same time. Around the first tree to succumb, eight or ten additional trees sometimes have died; (4) York Imperial is most susceptible to this disease. Stayman Winesap, Ben Davis, Yellow Newton (Albemarle Pippin) and Arkansas (Black twig) are apparently susceptible in the order named.

In all typical cases of root-rot the roots have been found invested with a delicate white mycelium. Sometimes the surfaces of the roots are cov-

[1] Reed, H. S., and Crabill, C. H. Notes on plant diseases in Virginia observed in 1913 and 1914. Virginia Agr Exp. Sta. Tech. Bul. 9. 1915.

ered with white to brownish rhizomorphs which branch profusely forming fan-shaped growths which adhere rather loosely to the bark. Some of these rhizomorphs were washed thoroughly by decantation and small pieces thrust into starch agar. Out of fourteen cultures thus made, twelve were pure cultures of a fungus which was tentatively classed as an Acrostalagmus but which was later identified by Mrs. Flora W. Patterson as *Trichoderma koeningi* Oudemans. The other two were contaminated by bacteria.

Following this, roots from trees showing typical symptoms of root-rot were collected in various parts of the state. In each case the root was trimmed, washed thoroughly in tap water, then in bichloride of mercury,

FIG 1 Apple tree roots affected with root-rot Photograph by H S Reed

1–1000, and split open with a sterile knife. With sterile forceps bits of the inner wood were picked out and thrust into starch agar in Petri dishes. Every root thus far examined has yielded Trichoderma.

After taking out the material for inoculation of the plates all of these roots were placed in moist chamber. Trichoderma fruited abundantly on all of them On one of the roots from Middletown, *Hydnum* sp. as well as Trichoderma produced spores. The root from Greenwood yielded, in addition to Trichoderma, a fungus which has not yet produced spores and which has not yet been identified.

The roots from Fishersville were small and still alive. On the wood, immediately under depressed areas of bark, were some oval darkened lesions with raised margins. When placed in moist chamber Trichoderma fruited abundantly on these lesions.

The average rate of growth of Trichoderma on starch agar at ordinary temperatures has been one centimeter every fifteen hours. This unusual rapidity of growth corresponds well with the sudden death of infected trees.

Trichoderma koeningi has been found to grow well on all culture media except those containing an excess of alkali. Lime or ground limestone is very detrimental to its growth. On fresh and well-rotted manure and on composted soil it made a rapid growth and produced abundant spores. On cellulose agar it grew poorly and fruited sparingly. Copper sulphate, 0.1 per cent, added to agar stimulated sporulation.

TABLE 1

Thrust cultures from rotted roots

DATE	LOCALITY	NUMBER OF CULTURES	TRICHODERMA	HYDNUM	CONTAMINATED BY BACTERIA	STERILE
1915						
April 5	Middletown	14	14			
April 12	Middletown	10	1	7		2
July 6	Roselands	10	6			4
July 6	Pleasant Valley	26	12		11	1
July 16	Fishersville	24	16		5	3
July 28	Greenwood	16	14		2	
July 28	Greenwood	16	9		5	2
Totals		116	72	7	23	12

Stained razor sections of typically affected roots show the fungus present in all the xylem elements. The pitted ducts are packed with the mycelium. The smaller wood cells are penetrated and the walls disintegrated. The cell walls are rendered very brittle. The mycelium is inter- and intracellular growing in all directions through the wood.

The facts presented above point to the conclusion that *Trichoderma koeningi* is the cause of a destructive apple root-rot in Virginia. While this organism may behave on apple only as a wound parasite there is some evidence that it is a parasite. Assuming that such is the case, the ability of this fungus to grow on dead organic matter, to spread by wind-blown spores or infected soil and to attack apple trees, make it a most formidable enemy of the apple industry in Virginia

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A TROUBLESOME DISEASE OF WINTER TOMATOES

J. E. Howitt and R. E. Stone

In the spring of 1914 tomato plants showing a marked diseased condition of the leaves, stems and fruit were sent to this department by a tomato grower living in the outskirts of Hamilton, Ontario. A visit was paid to the grower's forcing houses, and the disease was found scattered throughout two large houses, about 10 per cent of the plants being affected. The following December (1914) the trouble again appeared in one of these houses, and some three thousand plants were so badly diseased that the crop was a complete failure. The spring crop of 1915 in the same house was not seriously affected but many plants scattered here and there throughout the house showed clear evidence of the disease. The same spring some diseased plants were found in forcing houses in the vicinity of London and Toronto, Ontario. In August, 1915, the disease was observed on field tomatoes in two localities near Toronto, Ontario, about 1 per cent of the plants being affected.

The disease does not appear to be confined to Ontario. Bailey[1] describes a disease which he calls Winter Blight of Tomatoes. The symptoms given by Professor Bailey for this trouble in many respects strongly suggest that it may have been similar to the disease found in Ontario. Selby[2] described a blight of forced tomatoes which seems to the writers to be similar, if not identical, with the disease in Ontario. Tomato plants showing the characteristic symptoms of the disease were therefore sent to Professor Selby for examination. These were examined by one of Professor Selby's assistants, Mr. A. S. Orcutt, who reported as follows:

"Upon examining the tomato material, and later conferring with Professor Selby, it is our opinion that this is the same trouble which was reported from this section in 1896."

The same disease is also apparently found in the vicinity of Philadelphia. In January, 1915, diseased plants from forcing houses near Philadelphia were kindly sent to the writers by Mr. C. R. Orton, Plant Pathologist of the Pennsylvania State College. These when carefully examined, were found to have spots and lesions on the stems, leaves and fruits characteristic of the disease as it occurs in Ontario.

[1] Bailey, L. H. Some troubles of winter tomatoes. Cornell Univ. Agr. Exp. Sta. Bul. 43: 149-158. 1892.

[2] Selby, A. D. A blight of forced tomatoes. Ohio Agr. Exp. Sta. Bul. 73: 237 241. 1897.

SYMPTOMS OF THE DISEASE

This disease affects the leaves, stems and fruits. It is usually first observed on the young leaves of the terminals. Affected leaves show distinct brown and blackened areas scattered between the larger veins. These are angular, or somewhat diamond shaped, and are usually so numerous and close together that a distinct pattern is seen when affected leaves are held up to the light. An examination with a hand lens reveals the fact that the discoloration is not confined to the mesophyll of the leaf but extends to the secondary veins, and in some cases to the primary veins, so that a browning and blackening of the vascular bundles is clearly evident.

Affected leaves do not develop normally. They at first appear somewhat stunted and, as the disease progresses, droop and finally wither and die. In most cases observed the disease appeared to start on the upper younger leaves and gradually work downward to the older leaves.

On the stems of affected plants brown lesions are usually seen. These vary in size from mere specks to well-marked areas from 1 to 3 cm. long and about half as wide. They are not confined to any particular part of the stem, but are scattered throughout its length, being found just below the base of the petioles of affected leaves, at the base of healthy leaves, and frequently on the internodes some distance from the leaves. If cross sections of affected stems are examined under the hand lens the lesions are found to be almost entirely superficial, the discoloration being confined to the epidermal cells and to the outermost cells of the cortex. Many of these lesions were examined carefully by the writers, but in no case did the discoloration appear to extend into the vascular bundles, the lesions always appearing isolated and local. Professor Jones of the Bacteriological Department, however, reports that on examining some badly diseased plants, he found that the discoloration of the lesions appeared to extend into the vascular bundles.

Diseased fruits are characterized by brown sunken spots scattered irregularly over the surface and not confined to stem or blossom end. These vary very much in shape and size. They may be circular, oblong, angular or irregular in outline, and may be from less than a millimeter to 8 or 10 mm. in diameter. The surface of the spots may be smooth and unbroken, or cracked and scabby. Frequently the spots coalesce so that considerable of the surface of the fruit is brown and scabby. Often these diseased areas are chiefly confined to the grooves between the ridges on the surface of the fruit. Some of the spots are merely superficial, the discoloration not extending to any extent into the flesh of the fruit, while from others the discoloration extends deeply into the fruit and can be traced from the epidermis along the septa to the centre. If diseased fruits mature, the

affected areas fail to color normally and remain hard and green. Very frequently the diseased fruit falls without coloring. When the spots or lesions are well developed, the fruit is frequently more or less deformed, being spotted and scabby to such an extent as to render it useless for market purposes. When diseased fruits were removed from the plants and placed in a moist chamber, the spots failed to develop farther.

ATTEMPTS TO DISCOVER THE CAUSAL ORGANISM

When the diseased plants were received a superficial examination disclosed the blackening and browning of the vascular bundles of the leaves. This symptom suggested that the trouble might be the brown rot of tomatoes caused by *Bacillus solonacearum* E. F. S. Microscopic examinations were made but no fungus or bacteria were found associated with the lesions on leaves, stems or fruits. Dilution plate cultures were made but nothing was found to which the disease could be attributed. Fearing that in some way our technique might be at fault, specimens of diseased plants were submitted for examination to Dr. Erwin F. Smith, Bureau of Plant Industry, Washington, D. C.; Prof. A. D. Selby, Agricultural Experiment Station, Wooster, Ohio; Dr E. A. Bessey, Michigan Agricultural College; and Prof. D. Jones of the Bacteriological Department of Ontario Agricultural College. All of these gentlemen kindly examined the material supplied and reported the results of their findings. None of them found any organism capable of producing the disease.

EXPERIMENTAL WORK

Experiments were performed to determine if the origin of the disease was in the soil. Seed was obtained from the same lot of seed from which the first diseased tomato plants were grown. This seed was sown in fresh soil in which tomato plants had never been grown; the disease did not appear among the seedlings grown in this soil.

Soil was then obtained from the forcing house in which the disease first appeared. Part of this soil was sterilized, and this portion will hereafter be designated as sterilized soil. Part of soil was left unsterilized and will hereafter be designated as suspected soil. In addition soil which had never grown tomatoes was used and this will hereafter be designated as normal soil.

Seedlings grown in normal soil were then transplanted into three kinds of soil, namely, suspected soil, sterilized soil and normal soil. The plants transplanted to sterilized soil and normal soil all developed normally and produced sound fruit. Some of the plants transplanted to suspected soil were killed by the fungus Rhizoctonia but the remainder remained healthy

and produced sound fruit. The plants attacked by Rhizoctonia did not show any symptoms of the disease in question.

The above experiment was varied. Some of the same lot of seed used in the previous experiment was sown in suspected soil and some in normal soil. The disease did not appear in the seed-beds. Seedlings from the suspected soil and some from normal soil were then transplanted, some from each seed-bed into suspected soil, some into sterilized soil and some into normal soil so that six different combinations were obtained, namely, (1) Seedlings from suspected soil to suspected soil; (2) seedlings from suspected soil to sterilized soil; (3) seedlings from suspected soil to normal soil; (4) seedlings from normal soil to suspected soil; (5) seedlings from normal soil to sterilized soil; (6) seedlings from normal soil to normal soil. Six plants were used in each combination. The results were briefly as follows:

(1) Four of the plants developed the disease when the seedlings were grown in suspected soil and transplanted to suspected soil.

(2) Two plants developed the disease when the seedlings were grown in suspected soil and transplanted to sterilized soil.

(3) Two plants developed the disease when seedlings were grown in suspected soil and transplanted to normal soil.

(4) One plant developed the disease when the seedlings were grown in normal soil and transplanted to suspected soil.

(5) No plants developed the disease when seedlings were grown in normal soil and transplanted to sterilized soil.

(6) No plants developed the disease when the plants were grown in normal soil and transplanted to normal soil.

The interesting point to note in this experiment is the fact that the only plants which developed the disease were those which at some time had been grown in suspected soil, that is unsterilized soil in which diseased plants had previously grown. This experiment, while by no means conclusive, suggests that the origin of the disease may be in the soil.

INOCULATION EXPERIMENTS

A sterilized needle was inserted into diseased lesions of affected plants and then inserted into stems and leaves of healthy plants. Five plants were so treated. The plants were kept moist but no infection resulted. Checks were also free.

Portions of infected plants were enclosed with healthy plants under a bellglass. These were thoroughly sprayed with water in order to ensure a copious supply of moisture. No infection resulted.

Attempts were made to isolate fungi or bacteria from diseased tissue. Both acid and neutral agar were used as media. No fungi developed in

either. In the neutral agar a few bacteria developed. Some of these bacteria were introduced into the tissue of healthy plants by needle punctures and some were smeared upon the leaves and stems and the plants kept moist. The results were negative. This series of experiments was repeated, but again only negative results were obtained.

EXPERIMENTS WITH HYDROCYANIC ACID GAS

It was suggested by tomato growers that the diseased condition might be due to fumigating the forcing house with hydrocyanic acid gas to destroy the white fly. Attempts were therefore made to produce the disease by such fumigation. Tomato plants, both dry and with the leaves sprinkled with water, were placed in an air-tight box and fumigated with hydrocyanic acid gas. Four different strengths were tried, namely, one-third, one-half, two-thirds and one ounce of potassium cyanide per thousand cubic feet. Eighteen plants were used in each trial, nine dry and nine with the leaves sprinkled with water. None of the plants developed the diseased condition, but those fumigated with hydrocyanic acid gas of the strength of one ounce of potassium cynide to a thousand cubic feet of air space had the leaves badly burned.

SUMMARY

1. This disease is widespread and may result in serious loss.

2. Little is known as to the cause of the disease.

3. Repeated microscopic examinations and plate culture tests with various media have failed to disclose a causal organism.

4. Inoculation experiments have given negative results.

5. The position and nature of the lesions and the fact that the disease fails to develop further in affected fruits when these are removed from the plants and placed in a moist chamber indicates that this is a so-called physiological trouble.

6. Experiments with hydrocyanic acid gas indicate that fumigation does not cause the disease.

7. Experiments in sterilized soil seem to indicate that the origin of the disease is in some way connected with the soil, but as no causal organism has been found it would seem that the disease might be due to some chemical or physical deficiency in the soil, which is apparently overcome by sterilization.

8. This account of this disease is published with the object of again calling the attention of plant pathologists to it with the hope of stimulating discussion and research regarding its cause and control.

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RESISTANCE IN TOBACCO TO THE ROOT-ROT DISEASE

JAMES JOHNSON[1]

WITH SIX FIGURES IN THE TEXT

The differences in varietal susceptibility of tobacco to the root-rot disease, caused by *Thielavia basicola* Zopf, has been noted since the time of the discovery of this disease by Peglion in 1897. The possibility of producing resistant strains within susceptible varieties first came to the writer's attention in 1913. The prevalence of the disease in the tobacco fields of Wisconsin and Ontario, Canada, during that season, gave a good opportunity for the study of the nature of the trouble, and particularly favorable conditions for the selection of parent plants for disease resistance. Some of the results obtained in the past two years from a comparative study of the relative resistance of these selected strains and of certain varieties are thought worthy of publication at this time. It is expected that the problem will be continued and, consequently, the details of the work will be left for future presentation. For reasons of convenience a brief description of the nature of the disease, its occurrence, and economic importance is added.

NATURE OF THE DISEASE

Root-rot, or black-root, of tobacco is caused by the fungus *Thielavia basicola* Zopf. Plants affected with this fungus, which attacks only the roots, are characteristically stunted more or less in growth (fig. 1). The degree of stunting may vary from hardly perceptible decreased vigor to complete retardation of growth. Complete destruction of the plants occurs but rarely. In the former case the disease may be more injurious to quality than to yield, as is indicated by more or less marginal curling of the upper leaves and premature yellowing and death of the lower leaves. Crops often recover from serious early attacks of the disease, which, how-

[1] *Acknowledgments* The opportunity to carry on work in the Burley sections of Canada was made possible by the Imperial Tobacco Company of Montreal. The study of the occurrence and importance of the disease in various parts of the United States was done in cooperation with the Office of Tobacco Investigations, U. S. Department of Agriculture. The writer is indebted to Dr. L. R. Jones, Pathologist at the Wisconsin Experiment Station, Mr. T. S. Biggar, Superintendent of the Walker Sons Farms, and to Officials at the Harrow Experimental Farm, Ontario, Canada, for advice and assistance.

ever, result in late growth and maturity, thus directly injuring the quality or causing increased possibilities of damage by frost or of curing and packing-house troubles Complete crop failure sometimes occurs, but more often what may be called half-crops are harvested.

In bad cases of the disease the root system is characteristically deficient. Only two or three small new roots may be present on such plants. These roots function for a short period of time, only to be attacked by the

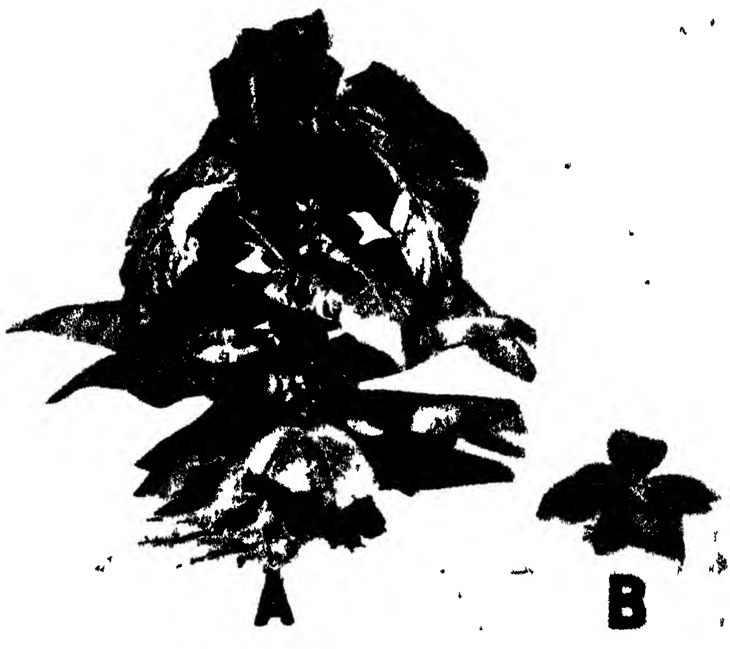

FIG. 1 Showing stunted growth of White Burley tobacco due to the root-rot disease Walkerville, 1914 *A*, Normal White Burley grown on healthy soil, *B*, diseased White Burley plant grown on diseased soil about one rod distant. Both plants grown in same row and from self-fertilized seed of same parent plant Age of plants in field about eighty days

parasite, and replaced by other new roots, by means of which the plant is enabled to maintain life. In less serious cases all the primary and secondary roots may be present, but show local areas attacked by the fungus. Such areas usually girdle the roots, are brown or black in color, scabby in appearance and frequently are hypertrophied. The tertiary roots, however, may be badly decayed on such plants, a condition which results in a markedly stunted growth. On the other hand, it appears that practically all the roots may be present, but, owing to small local

infections, the roots are unable to function properly, with resulting evidences of starvation in the leaves.

On the whole, the above-ground symptoms are characteristic of such conditions as may be brought about by lack of fertility or of water in the soil. The condition of infected fields, therefore, is often attributed erroneously to some form of malnutrition.

OCCURRENCE OF ROOT-ROT

Thielavia basicola has been known for some time as a common parasite on tobacco in Italy and in the United States. It has also been reported upon tobacco in Sardinia and in Cuba, and as occurring upon other plants in Germany, Russia, England, Belgium, and Korea.

In the United States it has been reported previously upon tobacco in Ohio, Connecticut, Kentucky and North Carolina. It has also been reported on violets, ginseng and other plants in Connecticut, Maryland, New York, Ohio, Pennsylvania, Vermont, Wisconsin, Michigan, Minnesota, Indiana, Illinois, Nebraska, Utah, and the District of Columbia. More recently it was reported by the writer[2] as a serious disease of tobacco in Wisconsin and Ontario, Canada. In 1915 the Thielavia disease was observed by the writer in Ohio, Kentucky, Pennsylvania, Connecticut and New York, in which states it appeared to be a most important factor in controlling crop production. In addition, the disease was found on specimens of tobacco from Virginia, Maryland, and Massachusetts. The occurrence and importance of this disease in the more southern tobacco fields remains to be ascertained. According to Dr. W. W. Garner, of the Bureau of Plant Industry, United States Department of Agriculture, the Thielavia root-rot occurs, however, in Florida, causing a very considerable amount of damage to shade-grown tobacco.

ECONOMIC IMPORTANCE OF THE DISEASE

Ordinarily the growers do not recognize the importance of this disease, owing to the obscurity of the infected parts, and the similarity of the symptoms in the aerial parts to the effects of impaired nutrition. Hence, the losses are generally attributed to such causes as soil sickness, soil deterioration, loss of fertility, excess or lack of water supply, or to the improper physical condition of the soil.

The root-rot disease appears to be especially prevalent in sections where the tobacco is grown upon the heavier types of soil, as in Wisconsin,

[2] Johnson, J. Resistance in Tobacco to Root-rot, (Thielavia basicola, Zopf). Phytopath. 4: 48. 1914

Ohio, Kentucky, Pennsylvania, New York, and parts of Canada. On the other hand, during wet seasons, very considerable damage may result on such light, sandy soils as those of the Connecticut Valley.

It seems probable that the root-rot disease is responsible in a large measure for the maintenance, if not for the development, of the present system of tobacco culture in the Burley sections of Kentucky and other states. This system of culture, which for best results requires a period of rest of five to ten years for the soils between crops of tobacco, appears to have been empirically developed in Burley tobacco culture, owing to the extreme susceptibility of this variety to the root-rot disease. Although this practice has made Burley culture possible, there is still a very considerable loss from the disease in the Burley sections. The Burley growers of Canada have not yet recognized the Kentucky system and have experienced increasing difficulty in growing satisfactory crops of this variety. The resting of land for long periods of time, is, however, generally impracticable in the northern tobacco growing sections, owing to the more restricted areas suitable for the culture of this crop.

A reliable estimate of the losses due to the root-rot disease is especially difficult to make. Such figures are of value, however, in giving a general idea of the importance of the disease which cannot be obtained in any other way. The annual losses in the United States certainly run into millions of dollars. The crop of 1915 probably suffered the most of any in the recent history of the disease, owing to the abnormally wet season. The loss conservatively can be placed at between ten and twenty millions of dollars for this year in the United States alone.

EARLIER WORK ON RESISTANCE IN TOBACCO

The root-rot of tobacco (*Thielavia basicola* Zopf.) was first reported by Peglion[3] in Italy in 1897, who noted at the same time a difference in varietal susceptibility. He noted particularly that the "Seed-leaf" type was much less damaged than the "Kentucky-Burley." Peglion recognized the disease as serious and recommended that varieties be studied in order to determine differences in resistance. Apparently following this investigator's recommendation, the study of varietal resistance to root-rot has been reported upon by several writers from Italy, but as far as known has not been worked upon in this country, although it was suggested as a possible means of control by Gilbert[4] in 1909. The Italian experimenters

[3] Peglion, V. Marciume radicale delle piantine di tabacco causato dalla Thielavia basicola, Zopf. Centralbl. Bakt., etc., 3: 580-584, (1897).

[4] Gilbert, W. W. The Root-rot of Tobacco caused by Thielavia basicola, Zopf. U. S. Dept. Agr. Bur. Plant Indus. Bul. 158: 9-43. 1909.

have been concerned mainly in comparing the resistance of varieties and hybrids, and apparently have not concerned themselves with producing resistant strains of a susceptible variety. Benincasa[5] in 1902 reported the native varieties of Italy more resistant to root-rot than the foreign varieties and noted that the Burley variety was the most susceptible of the introduced varieties. In contrast to the Burley he found a variety, Brasile Beneventano, to be particularly resistant and placed some other varieties in the order of their resistance to the root-rot disease.

At about the same time Barbatelli and Stazi[6] stated that the "heavy" tobaccos and hybrids suffer most from this disease, while the "light" tobaccos were only slightly attacked.

Buttaro,[7] also writing in 1902, presumably of the same work as that of Benincasa, notes that the Brasile Beneventano and Kentucky varieties give the best results and Burley the poorest results on infected soils. In a later note this writer[8] adds that as a result of an exceedingly wet season, the disease not only attacked the exotic varieties, but also the native variety Brasile Beneventano.

Benincasa[9] in 1911, writing further upon control measures against the root-rot disease, reports the trouble especially prevalent on the Kentucky tobacco, and recommends that the growers substitute a new strain of Kentucky for the pure Kentucky. A cross between the "Salento" and "Italia" varieties is said to be resistant to root-rot in the seed-bed and in the field, at the same time having other desirable qualities.

Aielli-Donnarumma[10] some time later reports upon the results of five years' investigation along this line. Numerous crosses were made between the "Kentucky," "Italia," "Moro," and "Salento" varieties, in an attempt to bring out resistant types. One hybrid, "Italia × Kentucky B," was developed which was apparently strikingly resistant to the root-rot disease. Other types, "Moro × Kentucky," and "Salento × Kentucky," were next best, but were, however, subject to attack from the fungus.

[5] Benincasa, M. Ricerche sui mezzi per difendere i semenzai di tabacco dal "marciume radicale" causato dalla Thielavia basicola, Zopf. Bol. Tecnic. d. coltiv. d. Tabacchi, **1**: 24-33. 1902.

[6] Barbatelli and Stazi. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi. Scafati. Bol Tecnic. d. coltiv. d. Tabacchi, **1**: 152. 1902.

[7] Buttaro, G. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi. Pontecorvo. Bol. Tecnic. d. coltiv. d. Tabacchi, **1**: 159. 1902.

[8] Buttaro, G. Notizie sull'andamento delle coltivazioni e cure dei Tabacchi, Pontecorvo. Bol. Tecnic d. coltiv. d. Tabacchi, **1**: 234. 1902.

[9] Benincasa, M. I semenzai di sabbia considerati quale mezzo di difesa contro il marciume radicale causato dalla Thielavia basicola, Zopf. Bol. Tecnic. d. coltiv. d. Tabacchi, **10**: 3-22. 1911.

[10] Aielli-Donnarumma. Meticci pesanti refrattori alla Thielavia al campo. Bol. Tecnic. d. coltiv. d. Tabacchi, **10**: 277-281. 1911.

Aielli-Donnarumma has in later notes[11] reported some of these resistant hybrids as satisfactory for commercial purposes in Italy. One of the Italia × Kentucky hybrids, in particular, gave good yield and quality on diseased soil. Later this same writer[12] reports excellent results in crossing two resistant hybrids in order to intensify the resistance and improve the quality.

Benincasa[13] published a paper in 1914 on some further observations of the root-rot disease. In this paper it is stated that the Burley, Kentucky, and Virginia types are the most susceptible, while the indigenous races possess considerably more resistance. Some of the small and eastern races of tobacco are also noted to be resistant.

Shamel and Cobey[14] noted resistance in tobacco to a "wilt" disease, and to the root-knot disease in the United States sometime previous to 1907. The latter disease is apparently erroneously referred to by Waite[15] as the root-rot disease in a general paper on disease control.

In 1913 a brief notice regarding the relative susceptibility of the Little Dutch, Connecticut Havana, and White Burley varieties to the Thielavia disease was published by the writer.[16]

METHODS OF WORK

The experimental work of testing varieties and strains has been performed in several different soils and localities. Most of the tests have been duplicated at least twice under different conditions and some trials have been repeated four or five times. The Burley work has been confined mainly to Ontario, Canada, and the cigar leaf selections to Wisconsin, although many Burley strains have been grown in Wisconsin and some cigar leaf strains in Canada.

In Canada the greater part of the work has been done at the Walker

[11] Aielli-Donnarumma. Risultati attenuti circa le destrivazioni d'impiego dai prodatti di meticci pesanti resistenti alla Thielavia basicola nel 1911 Bol. Tecnic. d. coltiv d. Tabacchi, **11:** 286. 1912.

— Risultati economici attenuti dalla coltura di meticci pesanti resistenti alla Thielavia basicola Bol Tecnic. d. coltiv. d. Tabacchi, **12:** 89. 1913.

[12] Aielli-Donnarumma. Su due combinati di tabacchi pesanti Bol. Tecnic. d. coltiv. d. Tabacchi, **13:** 7-8 1914.

[13] Benincasa, M. Sulla crescente incompatibilita di alcuni terreni per la coltura del tabacco "Kentucky. Bol. Tecnic. d. coltiv. d. Tabacchi. **13:** 273 287. 1914.

[14] Shamel, A. D. and Cobey, W. W. Tobacco Breeding. U. S Dept. Agr. Bur. Plant Indus. Bul. 96: 60. 1907.

[15] Waite, B M Vegetable Pathology and Economic Science. Congress of Arts and Sciences. Saint Louis Exposition, **5:** 165 173. 1904.

[16] Johnson, J. Resistance in Tobacco to Root-rot, (Thielavia basicola Zopf.). Phytopath **4:** 48. 1914.

Sons' Farms, Walkerville, Ontario. On this farm, where two or three hundred acres of tobacco are grown annually, the soil has been made extremely fertile by the use of animal manures, but has become so badly infected that Burley growing is commercially impossible, and more resistant varieties of dark tobacco are grown. Plots have been located also at the Dominion Experimental Farm at Harrow, and at Mr. A. Leslie's farm at Kingsville, at which places the soil is of a light, sandy nature and moderately fertile. In Wisconsin the plots have been located on a silt loam soil at the Experiment Station Farm, Madison, and on a clay loam soil at Edgerton.

The varieties used in the tests have been obtained from the most reliable sources. Most of the seeds have been secured from the United States Department of Agriculture, Office of Tobacco Investigations. Others were obtained from various experiment stations in this country and Italy, or from reliable seed growers and distributors. The selections for disease resistance within varieties were made in Ontario for the White Burley type and in Wisconsin for the cigar leaf types. A large number of fields, involving in the neighborhood of two thousand acres, were scrutinized in these sections for resistant parent plants. Where out-standing plants were found the seed-heads were bagged to insure self-fertilization and the plants labelled and numbered. Short notes were taken as to the desirability of the type and its superiority over the neighboring plants. In this manner forty-eight Burley selections and forty-two cigar leaf selections were originally made. The seed from each plant was saved separately and sown in separate plots of sterilized soil. When these plants were of the ordinary size for transplanting they were set into infected soil in progeny rows. Types of the most resistant and the most susceptible varieties were usually set in all plots as checks.

At intervals throughout the growing season estimates were made of the relative growth of the types, using 100 per cent as a basis for normal growth, usually represented by the most resistant type in the plot. Most of the data collected exist in the form of estimates, which were found to be fairly reliable when compared with computed relative yields from actual weights. Owing to the large number of cultures used it was found impossible to get the actual yields of cured leaves from each type and, moreover, many of the types never reached sufficient size or maturity to harvest for curing. In 1915 the green weight of the leaves and stalks of twenty-five plants from many of the types were taken for comparison, and these figures form the basis of this paper. In order to reduce the error likely to result from differences in vigor of growth of the types, the green weight of twenty-five plants of each type as grown on uninfected soil was also taken. The relative yield on infected soil is then computed on the basis of these

figures, which can be taken as a fairly close approximation of the relative resistance on each plot. The actual resistance can not be computed in this way since the result will naturally vary with the fertility of the uninfected soil, and the fertility and amount of fungus in the infected soil.

VARIETAL RESISTANCE

Varieties are frequently based upon somewhat small and unsatisfactory differences. Sub-varieties, local varietal names, and local strains are

TABLE 1

Comparative yield of tobacco varieties on uninfected and infected soil Madison, Wisconsin, 1915

VARIETY	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
	Uninfected soil	Infected soil	
	pounds	*pounds*	*per cent*
White Burley	66.5	3.0	4.5
Comstock Spanish	59.5	20.0	33.6
Connecticut Havana	45.0	20.75	46.1
Kentucky Greenleaf	49.75	3.0	6.0
Pennsylvania Broadleaf	82.5	14.0	16.9
Brasile Beneventano	56.6	41.25	73.0
Maryland Broadleaf	65.0	2.5	3.8
Italia × Kentucky	60.0	39.5	65.8
Big Oronoco	57.75	3.0	5.2
Ohio Seedleaf	70.5	15.25	21.6
Yellow Pryor	59.0	2.5	4.2
Black Seedleaf	84.25	23.25	27.6
Halladay Havana	58.5	33.25	56.8
Gregory's White Burley	59.75	1.75	2.9
Little Dutch	79.50	40.0	50.3
Montgomery Seedleaf	93.50	44.0	47.0
Maryland Narrowleaf	66.50	2.25	3.3
Cuban	28.25	5.25	18.5
Northern Hybrid	65.0	45.5	70.0
Golden Spanish	50.0	25.5	51.0
Silver Leaf	56.25	31.5	56.0
Page's Comstock	41.25	32.5	78.7
Pease Seed	49.0	37.25	76.0

very commonly confused among the growers as true varieties. Since any method of classification is necessarily arbitrary, the commercial names have been adhered to regardless of biological relationships. An endeavor has been made to include the important commercial varieties of the United States, the important strains of Burley tobacco as grown in

Kentucky and Ontario, and the important commercial types of cigar leaf tobacco as grown in Wisconsin. Two types, Brasile Beneventano and Italia × Kentucky, developed for disease resistance in Italy, have been included for comparison.

The relative yield of most of these types on uninfected and infected soil is shown in table 1. Reference to the column "Relative resistance" shows that a marked variation exists in the range of susceptibility of these types to the root-rot disease (fig. 2). Unfortunately, the varieties showing most resistance to disease are among the least extensively grown or are undesirable in quality for the purpose for which they are intended. Since there are fully eight or ten different types of tobacco grown for as many different purposes it consequently will be necessary to develop a resistant strain for each of these types, which will be satisfactory both as

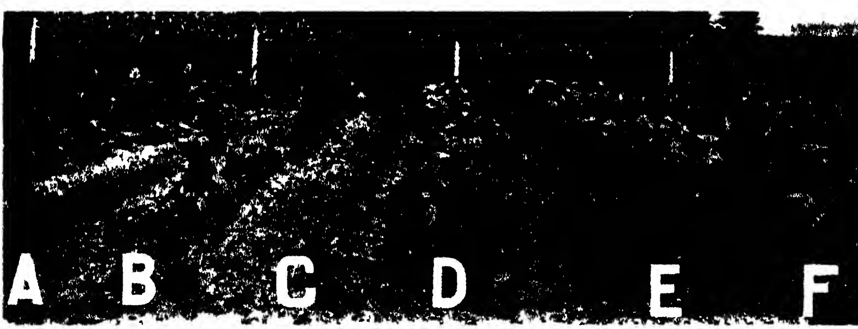

FIG. 2. Differences in varietal resistance to root-rot. Madison, 1915. A, Yellow Pryor; B, Ohio Seedleaf; C, Big Oronoco; D, Italia × Kentucky; E, Maryland Broadleaf; F, Brasile Beneventano.

to yield and quality. White Burley is one of the most extensively grown types and also one of the most susceptible, consequently the greatest interest centers around selections in this variety.

THE WHITE BURLEY SELECTIONS

The trials with White Burley have consisted in testing out the major portion of the forty-eight parent plants selected for resistance in Ontario in 1913, and in comparing the best local strains of White Burley grown in the the United States and Canada. In dealing with White Burley as grown in Canada it was found that on the whole the types were not uniform in the field. Frequently as high as one to two per cent of the plants in the field did not have the color characteristics of the White Burley. The stalks, midribs and veins on these plants were decidedly green and not creamy

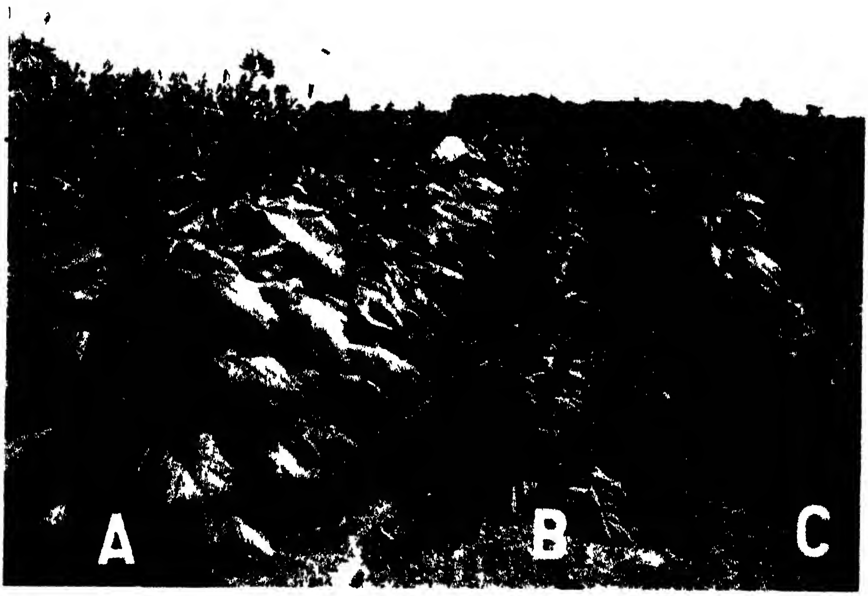

FIG 3 Showing resistance of 'green Burley' type to root-rot Walkerville, 1914 *A*, Burley selection (P705) green *B*, White Burley (Strain Broadleaf), *C*, White Burley Selection (J805)

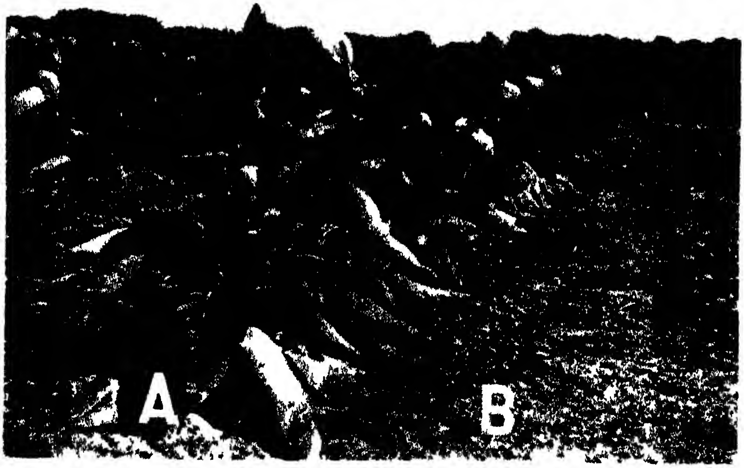

FIG 4 Showing effect of selection on development of resistance to root-rot within the White Burley variety Madison, 1915 *A*, White Burley selection, (P701B), *B*, Ordinary White Burley.

white as is characteristic of these parts in normal White Burley. These "off-type" plants are ordinarily called "mongrels" or "green Burleys" by the growers. It was also evident that these green Burleys were usually much more resistant to disease than the ordinary White Burleys (fig. 3). Some of the most resistant green Burley types were selected with the idea that they might throw off resistant true or White Burleys. A few of these green Burleys bred uniformly resistant and true to type, while others

TABLE 2

Comparative yield to tobacco on uninfected and infected soil. Ontario, Canada, 1915

NUMBER	VARIETY OR STRAIN	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
		Uninfected soil	Infected soil	
		pounds	*pounds*	*per cent*
1913	Halley's White Burley	49 0	0 25	0 5
B1197	White Burley Selection	41 5	14 25*	34 3
B1198	White Burley Selection	47 5	18 0	37 9
B1193	White Burley Selection	57 5	24 5	42 6
J80312	White Burley Selection	42 5	7 0	16 4
J80314	White Burley Selection	31 5	2 5*	7 9
I803B	White Burley Selection	42 0	7 0	16 6
B121	Broadleaf Standup Burley	60 0	7 25	12 0
B1211	Broadleaf Standup Burley	69 5	6 75	9 7
1910	Gregory's White Burley	78 0	0 50	0 6
P701B	White Burley Selection	69 0	8 0	11 6
1924	White Burley Selection	79 0†	9 5†	12 0†
1925	White Burley Selection	41 0	6 0	14 6
B1092	White Burley Selection	72 0	0 25	0 3
B1131	Thompson's White Burley	62 0	0 50	0 8
S6207	Pryor Selection	45 0	2 0	4 4
S6161	Pryor Selection	47 5	3 5	7 3
S6041	Pryor Selection	50 0	2 5	5 0
	Barnard's White Burley		0 25	
1919	Connecticut Broadleaf		17 75	
H12031	Cigar Leaf Selection		33 0	

* Outside row † Green Burley type

split up into green and white Burleys, some of the latter showing marked tendencies toward resistance. Further selections with true Burleys developed from this source have proved to be the most resistant of any strains obtained. Selections B1193 and P701B are representative of this type (table 2 and fig. 4). The former is, as far as can be determined in the field, a normal White Burley type with a resistance which is, in some cases, over one hundred times greater than ordinary Burley on very badly diseased soil. Selection P701B is seemingly not yet fixed in type,

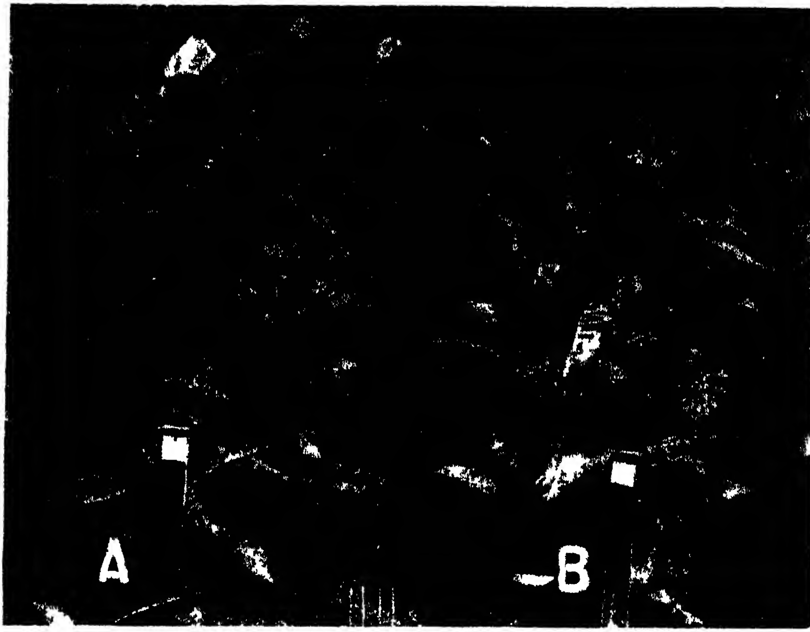

FIG. 5 Relative resistance of two cigar leaf strains selected for resistance from a grower's field. Illustrates cause of uneven growth in diseased fields when impure seed is used. Madison, 1914. A, Cigar Leaf Selection 1403; B, Cigar Leaf Selection 1401.

FIG. 6 Relative resistance of White Burley strains. Walkerville, 1914. A, Burley Selection (J803), B, White Burley (Stoner Strain), C, Burley Selection (B119) from which best Burley strain (B1193) was obtained.

but promises to be as good as or better than selection B1193. Selection J803 came directly from a fairly good Burley parent and possessed considerable resistance from the start, but it is not as promising as B1193 in either quality or resistance.

From the twenty local strains of White Burley grown in the Burley sections, only one exhibited any degree of resistance. This was a strain known as Broadleaf Standup Burley, which probably was empirically developed as a semi-resistant type.

CIGAR LEAF TOBACCO SELECTIONS

The cigar leaf tobacco selections have been confined practically to this type as grown in Wisconsin for cigar binder purposes. The two varieties commonly grown in this state are Comstock Spanish and Connecticut Havana, both of which are practically identical with the Havana Seed type as grown in Connecticut. These types are losing favor with the growers on account of the fact that they give small yields on old tobacco soils, apparently regardless of fertility. The result has been the introduction of a number of coarser-growing types which are in some cases regarded as inferior in quality by the manufacturers, but usually give satisfactory yields from the grower's standpoint. The advantage of these coarser types (locally known as Seedleaf, Big Seed, Hybrid, and so forth) is now known to be due to their more marked resistance to disease. In table 1, Page's Comstock, Pease Seed and Northern Hybrid are representative of this type. On uninfected soil these types yield on the average no more than the Comstock Spanish or Connecticut Havana varieties.

The striking unevenness in size of plants frequently observed throughout infected fields of both cigar and Burley tobaccos is generally due to the use of impure strains of seed on infected soil (figs. 5 and 6). The same condition can usually be brought about by growing the second filial generation of a cross between a susceptible and resistant type on infected soil. Where known pure strains of seed are grown the plants are invariably uniform as to size in the row, whether a susceptible or a resistant type is grown, except for such variations as may be due to soil-differences. Opportunities for selection of resistant types have, therefore, not been found where pure seed has been used but in fields where mixed types occur. Forty-two parent plants of apparently resistant cigar leaf types were selected from Wisconsin fields in 1913. The seed of most of these were tested out in 1914 and 1915. The relative yield of some of these as grown in 1915 on uninfected and infected soil are shown in table 3. Unfortunately, the infected soil in this case was more fertile than the uninfected soil, so that there was a greater yield on infected soil than on unin-

fected soil for the most resistant types. The relative resistance, therefore, in some of these types rises above 100. Strain H12031 has consistently shown a degree of resistance considerably above any other type of tobacco which has yet been grown.

TABLE 3

Comparative yield of tobacco on uninfected and infected soil. Madison, Wisconsin, 1915

NUMBER	VARIETY	GREEN WEIGHT OF TWENTY-FIVE PLANTS		RELATIVE RESISTANCE
		Uninfected soil	Infected soil	
		pounds	*pounds*	*per cent*
1401	Cigar Binder Leaf Selection	29 25	40 0	136 7
1403	Cigar Binder Leaf Selection	21 50	19 25	89 5
14032	Cigar Binder Leaf Selection	28 25	21 75	76 9
1405	Cigar Binder Leaf Selection	39 25	25 25	64 3
16011	Cigar Binder Leaf Selection	34 25	25 75	75 1
1602	Cigar Binder Leaf Selection.	36 50	22 5	61 6
1604	Cigar Binder Leaf Selection	34 50	29 25	84 7
1605	Cigar Binder Leaf Selection	34 0	25 5	75 0
18011	Cigar Binder Leaf Selection	38 0	41 5	109 2
18021	Cigar Binder Leaf Selection	35 0	29 0	82 8
1803	Cigar Binder Leaf Selection	43 0	47 5	110 4
H1201	Cigar Binder Leaf Selection	37 5	39 75	106 0
H1202	Cigar Binder Leaf Selection	25 0	41 0	164 0
H12031	Cigar Binder Leaf Selection	36 0	57 0	158 3
H12035	Cigar Binder Leaf Selection	38 5	60 0	155 6
H1206	Cigar Binder Leaf Selection	37 0	47 75	129 0
H12071	Cigar Binder Leaf Selection	42 25	56 0	132 5
H12074	Cigar Binder Leaf Selection	42 50	56 75	133 5
3330422	Connecticut Havana	36 5	24 5	67 1
	Gregory's White Burley	48 75	3 5	7 1
B1193	White Burley Selection	55 0	29 5	53 6
P701B	White Burley Selection	42 5	32 5	76 4

The quality for commercial purposes of the more resistant of these strains has not yet been determined. Resistant strains with the quality of the Havana Seed are desired. Such types can no doubt be obtained, provided the trials are conducted on a sufficiently extensive scale.

SUMMARY

1. The root-rot of tobacco, caused by *Thielavia basicola* Zopf, is one of the most prevalent and the most serious diseases of tobacco in the United States and Canada.

2. The disease occurs in practically all the northern tobacco-growing sections, and in the Burley-growing sections of the South. Its occurrence and importance in the more southern-growing sections has not yet been determined.

3. The importance of the disease is not ordinarily recognized by the growers owing to the obscurity of the diseased parts, and the similarity of the above-ground symptoms to effects brought on by improper chemical, physical, and moisture relations of the soil.

4. A marked varietal difference exists in resistance to the root-rot disease. Of the standard types, the White Burley, Oronoco, Pryor, and Maryland groups are most susceptible. The Little Dutch and Connecticut Broadleaf are most resistant, while the Havana Seed type occupies an intermediate degree of resistance.

5. A strain of White Burley has been developed which possesses a high degree of resistance to the Thielavia root-rot. On very badly infected soils the yield of this type was in some instances over one hundred times greater than that of the ordinary Burleys.

6. Strains of cigar leaf tobaccos exist and can be isolated which are practically immune to this disease. On the whole, however, the quality of these types for commercial purposes is apparently unsatisfactory. There seems to be no reason, however, why resistant types with desirable qualities should not be found.

7. The production of disease-resistant strains of tobacco promises to become the most satisfactory and most practical method for the control of the root-rot disease of tobacco.

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AN OUTBREAK OF WHITE PINE BLISTER RUST IN ONTARIO

J. E. Howitt and W. A. McCubbin

Cronartium ribicola Fisch. de Waldh., was first observed in Ontario on a young currant plantation at the Ontario Agricultural College, Guelph, in September 1914. The rust was most abundant on black currants, but was also present to some extent on red currants and gooseberries. During the following week it was also found on currants in the Niagara District near Winona.

Though the season was late a survey was commenced to ascertain to what extent the rust was present in the Province generally. It was found in abundance in the region lying along the southern shore of Lake Ontario from the Niagara river to Hamilton, and along the northern shore from Hamilton eastward as far as Oakville. This region, which comprises an area of approximately 350 square miles, is mainly devoted to fruit growing, and therefore currant plantations are numerous and close together. Scattered through this section are also a number of nurseries, in many of which imported white pines are kept in stock. In addition, second-growth white pines are numerous, especially along the escarpment bounding this district on the south. The rust was also found in the Fonthill nursery district lying midway between Lake Erie and Lake Ontario.

In 1915 this survey was continued. The disease was again present during this season in all the areas where it had occurred in the preceding year, and in addition was found on currants in the following counties: Haldimand, Brant, Durham, and Elgin. Of these counties, Haldimand adjoins the main area of infection already noted; Brant is 25 miles from it; while Durham and Elgin are distant about 60 and 120 miles respectively.

The Peridermium stage was found on imported white pines in the following counties—the number of infected trees in each county being stated: Brant (2), Durham (2), Halton (8), Welland (4), Wellington (6), and Wentworth (24). In addition about 200 infections were found in a grove of native pines in Welland County. It is interesting to note that while specimens of *P. cembra* Linn. and *P. parviflora* Sieb. and Zucc. were found in several nurseries, none of these were affected with rust. The evidence appears to be clear that the rust was introduced into Ontario in recent years on white pine nursery stock imported from Europe; from Germany

and probably also from France and Holland. In the majority of cases the individual outbreaks can be connected definitely with the presence of some of these trees in the vicinity.

The following is a list of the species of cultivated and wild Ribes on which *Cronartium ribicola* has been found: *Ribes nigrum*, L., *vulgare* Lam., *grossularia* L., *aureum* Pursh., *cynosbati* L., *triste* Ball., *floridum* L'Her., *prostratum* L'Her.

No records were obtained of the susceptibility of native species, but the degree in which infestation occurs on a number of the cultivated varieties was determined to some extent in the plantations at the Ontario Agricultural College. Black currants, *R. nigrum,* were in all cases found to be more susceptible than other cultivated species, and among these the following varieties were badly attacked: Champion, Naples, Climax, Boskop Giant, and Kerry. Among red and white currants the disease was present on the various varieties to the following extent: Ruby Castle, 24 per cent, Victoria, 21 per cent, Cherry, 14 per cent, Fay, 10 per cent, Red Cross, 5 per cent, Magnus, 1 per cent, London Red, 0 per cent.

Gooseberries appeared to be more resistant than either red or black currants, as only two bushes among several hundred were affected. These two, however, were badly affected with the disease.

From numerous field observations made by the writers it was evident that the rust could pass from currant to currant across an interval of nearly half a mile. In one case this distance was ascertained by actual measurement to be 800 yards, but the occurrence of the disease in many isolated currant plantations gives rise to a strong suspicion that the distance over which infection may be carried is very much greater than this.

The question as to whether currant infection in spring must invariably come from a diseased pine, or whether in some cases it may arise from a wintering over of the fungus on the currant itself, is of such extreme importance that several experiments on this phase of the subject were undertaken.

1. In the fall of 1914 sixteen black and seven red currant bushes and one gooseberry bush, all badly rusted, were stripped of leaves and placed in cold storage, where they remained until March 16, 1915. At this date they were removed and planted in a greenhouse. All grew well and produced healthy leaves and fruit, and were entirely free from rust throughout the summer. In addition seventeen black currant bushes which had been badly rusted in 1914, and which were wintered in the field, were added to the above on April 21, 1915. These also grew normally and without rust.

2. Seventy-eight black currant bushes badly rusted in 1914 were wintered in the nursery rows, and transplanted April 21, in various gardens, isolated

as far as possible from infected white pines and currants. These were inspected six times during the summer, the last inspection being made October 2. At this date all were still free from rust except two bushes, on each of which a few rusted leaves were found. There is reason, however, to suspect that these infections might have been due to spores carried from currants about a mile distant from the garden in which they occurred. In no case was rust found on any of these currants which were located more than a mile from a source of infection.

3. A number of bushes from the same source as No. 2 were planted in five lots in a region known from personal observation to have been entirely free from the rust in 1914, and which is 60 miles from the nearest known source of infection. Of the 100 bushes set out here only one developed rust, and this late in the season. All conceivable sources for this infection have been accounted for except two, viz: the wintering over of the rust on the currant itself, or accidental infection from spores carried on the writer's clothing while making an inspection on May 24.

4. Attempts were also made to produce infection from the rusted leaves of the preceding year wintered out of doors. All such attempts gave negative results.

An endeavor was made to control the rust on currants by the use of bordeaux mixture and soluble sulphur, applied every two weeks throughout the summer. In spite of the exceedingly wet weather encountered, which was conducive to the spread of the disease and at the same time interfered with the effectiveness of the mixtures employed, the results indicate that, while the rust cannot be eliminated entirely by this means, it can be prevented from doing any serious harm to the currant leaves. In this connection it may be noted that while the European currant rust is not regarded by pathologists in general as a serious disease, yet here in Ontario it has for the last two years (1914-1915) been responsible for the early and almost complete defoliation of numerous plantations of black currants. Such defoliation must of necessity decidedly inpair the vitality of the bushes.

SUMMARY

1. Currant rust has been found in nine counties in the Province of Ontario.

2. The Peridermium stage has been found on both imported and native white pines, and the Cronartium stage on five cultivated and four wild species of Ribes.

3. Black currant plantations have in many cases been severely injured.

4. Imported white pines have been clearly shown to be the source of infection in the majority of cases.

5. According to observations the rust passes from currant to currant over an intervening distance of at least 800 yards.

6. The results of spraying experiments indicate that the rust on currants can be markedly reduced by repeated applications of bordeaux mixture or soluble sulphur.

7. Some evidence has been obtained which suggests that the rust may possibly winter on the currant, although the majority of tests on this point gave negative results.

In conclusion the writers wish to acknowledge the efficient service rendered in connection with the survey and experimental work with White Pine Blister Rust by Dr. R. E. Stone, Lecturer in Botany, Ontario Agricultural College, who made many of the field observations and experiments and Mr. Alfred Cleeves, Mr. G. O. Madden and Mr. D. R. Sands, field assistants, who examined most of the pine and currant plantations in the counties inspected.

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PRELIMINARY STUDIES ON THE RESISTANCE OF PRUNUS TO ARTIFICIAL INOCULATION WITH BACTERIUM TUMEFACIENS[1]

CLAYTON O. SMITH

WITH PLATE VI

From the studies of Dr. Erwin F. Smith and his associates, came our knowledge of the relation of *Bacterium tumefaciens* to grown gall and of the large number of hosts capable of being infected. All plants, however, did not prove equally susceptible and this suggested that possibly some of the species of Prunus might be much more resistant to the disease than were those the stocks of which are now being used for the various stone fruits. A more resistant stock is needed especially for the various stone fruits, including almonds, because of the following reasons: (1) The disease is widely distributed in orchards and nurseries, and has a deleterious effect on the orchard trees; (2) the most careful examination of such nursery stock before planting fails to eliminate the tree having incipient crown gall; (3) a more resistant stock could be planted in soils which are infected from previous plantings of trees or vines without the danger of contracting the disease as is often the case with the stock now in use.

The plan as finally adopted for determining resistance to crown gall, was to inoculate different kinds of Prunus at intervals of a week from May to September. Ten inoculations by puncture were made on the current year's growth at each test. Both resistant and susceptible kinds were included, as the viability of the culture could thus be known and a comparative test of the relative resistance secured. The organism was grown in pure cultures on standard nutrient agar to which one-half per cent dextrose was added. On this medium a vigorous raised-up growth was formed in sufficient quantities, after twelve to eighteen hours, to be used in making inoculations. No effort was made to protect the punctures in any way, as this was not at that time regarded as necessary. Moreover, the use of wax or other means of protection often causes an enlarged callus-like growth that could be confused easily with enlargements caused by *Bacterium tumefaciens*.

[1] Paper No 24, Citrus Experiment Station, College of Agriculture, University of California, Riverside California

The various species of Prunus were secured from several reliable sources; seeds and scions from the Arnold Arboretum; trees and scions from nurseries, and scions from some of the Experiment Stations. In the experimental work three different strains of the organism were used; number 694 was used in the preliminary work[2] and came from peach seedlings, number 753 was isolated from almond galls on April 14, 1913, and number 790 was isolated in 1914 from a peach gall on a large orchard tree.

In the inoculation experiments, cultures that had been growing in the laboratory for two years, were found to be still viable. Cultures that have been under cultivation for at least a year have been used from choice in the hope that there would be a slight decrease in virulence and hence a better showing of relative resistance in the plants under experimentation. No difference in the behavior and viability of these cultures was observed. Check inoculations showed negative results.

The following are the species of Prunus thus far tested by artificial inoculations: *Prunus allegheniensis*, *P. americana*, *P. amygdalus*, *P. Andersonii*, *P. armeniaca*, *P. armeniaca*, var. *Mikado*, *P. avium*, *P. Besseyi*, *P. caroliniana*, *P. cerasifera*, *P. cerasifera*, var. *planteriensis*, *P. domestica*, different varieties, *P. eriogyna*, *P. glandulosa*, *P. hortulana*, *P. ilicifolia*, *P. integrifolia*, *P. Mume*, *P. Munsoniana*, *P. nigra*, *P. orthosepala*, *P. pennsylvanica*, *P. persica*, *P. platycarpa*, *P. pumila* (Linn.), *P. serotina*, *P. Simonii*, and *P. Watsoni*.

All the above hosts developed typical galls from artificial inoculations, except *P. pumila*, *P. ilicifolia* and *P. caroliniana*. These three hosts were inoculated both during 1913 and 1914 and have always showed negative results. *P. ilicifolia* and *P. caroliniana* were on their own roots and were not making very rapid growth at the time of the experiment, but it seems almost impossible that the host should not have been in a susceptible condition at some time during the period from May to September.

The sand cherry, *P. pumila*, was inoculated with cultures of *Bacterium tumefaciens* every week from June 20 to August 31, 1914. In all, eleven series of ten punctures each or a total of 110 stabs were made during this time without the development of a single gall at the close of the growing season. Further inoculations of *P. pumila* (thirteen series of ten punctures each or 130) made during 1915 on vigorous growing seedlings, gave negative results, agreeing with the work of the two previous years. The experiments thus far show this host to be entirely resistant. *P. Besseyi* also showed strong resistance.

German Prune, *P. domestica*, was inoculated with cultures of *Bacterium tumefaciens* in accordance with the general plan above. The first inocula-

[2] Phytopath. 3: 59. 1913; California Agr. Exp Sta. Bul. 235

tions were made on May 3, 1914 and the last on August 31, 1914, in all 240 stabs being made. Twelve sets of experiments of ten punctures each were made in rapidly growing twigs of a seven-years-old tree, none of which were successful. Five cases of positive infections resulted from the inoculations on young trees two years from the nursery. The first ones from inoculations on June 29, the last from inoculations on August 24. The number of galls formed, ran as folows: 6, 6, 2, 2 and 8, and in size they ranged $\frac{1}{16}$ to $\frac{3}{16}$ of an inch in diameter.

TABLE I

Artificial inoculations on Italian Prune (Fellenberg) Prunus domestica. Concluded November, 1914

EXPERIMENT SERIAL NUMBER	DATE 1913	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
211	May 10	5	0	
216	June 1	5	2	$\frac{4}{16}-\frac{1}{16}$
252	June 13	5	0	
264	June 16	5	0	
270	June 17	5	0	
282	July 14	15	5	$\frac{2}{16}-\frac{2}{16}-\frac{3}{16}-\frac{4}{16}-\frac{8}{16}$
292	July 15	5	0	
315	July 19	6	2	$\frac{2}{16}-\frac{4}{16}$
328	July 21	6	1	$\frac{2}{16}$
332	July 21	5	0	
343	July 22	5	0	
355	July 25	10	4	$\frac{1}{16}-\frac{3}{16}-\frac{2}{16}-\frac{1}{16}$
366	July 30	10	0	
259	June 9	5	0	
375	July 30	10	0	
390	August 9	10	0	
406	August 14	10	3	$\frac{2}{16}-\frac{1}{16}-\frac{1}{16}$
420	August 14	5	0	
		127	17	

A detailed account of the experiments on Italian (Fellenberg) prune, *P. domestica*, is given in Table I. Parallel inoculations with those given in this table were made on other hosts of Prunus, and the cultures were found to be in a virulent condition.

The condition of the inoculations tabulated in Table I on September 30, 1915, are here briefly summarized, the number referring to the same experiment as shown in Table I.

216. A single large gall has developed one foot from the surface of the soil. This gall extends about one-half the distance around the trunk of the tree and measures $3\frac{1}{2}$ inches in diameter.

282. These inoculations were made on three Italian (Fellenberg) prune scions grafted on apricot root. Four galls were found having a diameter of 2 to 3½ inches. The infected branch measured 1½ to 2 inches in diameter.

315. These inoculations show four galls varying considerably in size: one gall 2 inches in diameter (Plate VI, fig. 4); one gall ½ inch in diameter (Plate VI, fig. 4); one gall ⅛ inch in diameter; one very small gall that can only with difficulty be distinguished from the tissue.

It will be noted that two galls have appeared since the results were tabulated.

406. Two small galls not showing any increase in size over that indicated in tables.

The experiments for 1914 on this species (Table V) showed nearly the same percentage of positive inoculations. In general, many of the galls on resistant stock often fail to show further increase in size after the first year while others grow to considerable dimensions. The positive galls grow out more at right angles than do those on more susceptible stocks and do not so nearly surround the infected twig. Inoculations on resistant stock that fail to show gall formation the first season rarely ever do so later.

Data on the present condition of galls produced on German prune show a very similar condition to those on the Italian prune (Fellenberg) and will not here be repeated.

Myrobolan stock, *P. cerasifera*, was also thoroughly tested, trees from three different sources being used.

1. Vigorous growing twigs of a large six-years-old tree were inoculated one week apart by puncture from May 5 to August 31, 1914. There were fifteen series of ten punctures each, and from these 150 punctures, 150 galls developed, which varied in size from ¼ to 1½ inches.

2. Inoculations made in vigorous growing sprouts of three-years-old roots gave nearly as good results as the above. On these, 120 inoculations were made in twelve series of ten stabs each. At the close of the growing season, 117 galls had developed.

3. The results from inoculations on a small myrobolan tree, the scions of which were secured from the Arnold Arboretum, showed much more resistance and are shown in Table II.

Prunus hortulana is regarded by many nurserymen as a good stock, especially for the native plums. Both seedlings and grafted trees have been tested. Thus far no marked resistance has been discovered, except with the variety known as Golden Beauty. The inoculation on this host for 1915, showed only 40 per cent infection. These inoculations were made in scions grown for the first season on peach stock. Vigorous growth of the inoculated twigs took place during the season, thus giving ideal

conditions for galls to develop. The inoculations of this host during 1914, showed much more resistance and are shown in Table III.

TABLE II

Artificial inoculations on Prunus cerasifera. Arnold Arboretum type. Concluded November, 1914

EXPERIMENT SERIAL NUMBER	DATE 1914	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
595	June 20	10	10	$\frac{1}{4}$–$\frac{1}{2}$
646	June 29	10	8	$\frac{1}{16}$ $\frac{1}{16}$
709	July 6	10	9	$\frac{1}{16}$–$\frac{1}{8}$
776	July 13	10	8	$\frac{1}{16}$ [illegible]
822	July 20	10	5	$\frac{1}{16}$
902	July 27	10	8	$\frac{1}{8}$–$\frac{1}{4}$
963	August 3	Check	0	
A 41	August 10	10	4	$\frac{1}{4}$ $\frac{1}{8}$
A111	August 15	10	2	$\frac{1}{16}$
A149	August 17	10	4	$\frac{1}{16}$
A225	August 24	10	10	$\frac{1}{16}$ $\frac{1}{4}$
A253	August 31	10	2	$\frac{1}{16}$
		110	70	

TABLE III

Artificial inoculations on Golden Beauty Prunus hortulana Concluded November 1914

EXPERIMENT SERIAL NUMBER	DATE 1914	NUMBER OF INOCULATIONS	INFECTIONS	SIZE OF GALLS
				inches
600	June 20	10	7	$\frac{1}{16}$
651	June 29	10	3	$\frac{1}{16}$
714	August 6	10	5	$\frac{1}{16}$ $\frac{1}{8}$
780	August 13	10	0	
826	August 20	10	4	$\frac{1}{16}$
906	August 27	10	1	$\frac{1}{16}$
967	September 3	Check	0	
A 11	September 4	10	3	$\frac{1}{8}$
A 44	September 10	10	0	
A114	September 15	10	1	$\frac{1}{16}$
A152	September 17	10	1	$\frac{1}{16}$
A250	September 29	10	0	
		110	25	

The two succeeding tables, IV and V, show considerable variation in results of the different hosts. There is, however, a reasonable degree of

consistency between the percentages of the different hosts for the two years during which the tests were made. The few seedlings of *P. pumila* that were inoculated during the year 1913, showed negative results, and *P. Besseyi*, the western sand plum, is strongly resistant. The next two hosts that should be considered are the German prune and the Italian (Fellenberg) prune. These belong to the group Domestica, a group containing many different varieties, some of which are being further tested for crown gall resistance. The two members of the group Domestica, referred to above, were the ones that have thus far shown the most marked resistance, but some of the other members of this group may be expected to have this characteristic. It is interesting to note that the German

TABLE IV

Summary of artificial inoculations on Prunus Concluded October 3, 1913

SPECIES	VARIETY	NUMBER OF INOCULATIONS	INFECTIONS	PER CENT OF GALLS	SIZE OF GALLS
					inches
P. domestica	German Prune	75	2	2⅔	$\frac{1}{16}$–$\frac{1}{8}$
P. domestica	German Prune	50	5	10	$\frac{1}{10}$–$\frac{1}{8}$
P. domestica	Italian Prune	127	17	13	$\frac{1}{16}$–$\frac{1}{4}$
P. domestica	Reine Claude	17	4	23	$\frac{1}{16}$–$\frac{3}{8}$
P. insititia	Damson	138	51	37	$\frac{1}{4}$–$\frac{3}{4}$
P. domestica	Duane's Purple[1]	37	15	40	
P. persica	Elberta	61	57	93	$\frac{1}{2}$–$2\frac{1}{2}$
P. triflora × P. Simonii	Wickson (hybrid)	56	64	98	$\frac{1}{2}$–1
P. triflora	Burbank	31	31	100	$\frac{1}{4}$–$\frac{1}{2}$
P. cerasifera	Myrobolan	8	8	100	$\frac{1}{2}$–1

[1] A local commercial stock, propagated in California from sprouts, and belonging probably to the Damson type, as it is a small blue plum having the same flavor but differing in shape.

prune is described as being one of the plums longest under cultivation, and the oldest of the prune type. Seedlings came reasonably true, which might be important if it should ever come into general use as a stock. The Italian (Fellenberg) prune has a history of over a century, so is not a new plum. The resistance of these plants cannot in any way be regarded as due to slow growth, for the experiments were on rapidly growing scions or on growth stimulated by pruning of young trees.

The members of the Damson group appear to show considerable resistance, although the variety of *P. insititia*, known as *pendula*, is rather susceptible. Probably in this group, as in the group Domestica, considerable difference of resistance will be found.

The peach, *Prunus persica*, possibly should be tested somewhat farther,

TABLE V

Summary of inoculations made on Prunus. Concluded November 15, 1914

SPECIES	VARIETY AND SOURCE	NUMBER OF INOCULATIONS*	INFECTIONS	PERCENTAGE OF INFECTION	SIZE OF GALLS
					inches
P. pumila	2 varieties, Arnold Arboretum	110	0	0	
P. domestica	Italian Prune	140	10	7	1/16–1/8
P. cerasifera	P. Planteriensis	40	3	7½	1/16–1/8
P. domestica	German Prune	240	24	10	1/16–1/4
P. insititia	Damson	120	13	10	1/8–1/2
P. Besseyi		50	5	10	1/8–1/2
P. hortulana	Golden Beauty	110	25	22	1/16–1/8
P. Amygdalus†	Bitter Almond	100	22	25	1/8–3/8
P. domestica	Reine Claude	90	25	26	1/16–1/2
P. Armeniaca	Mikado	40	11	27	1/16–3/16
P. angustifolia	Watson	50	15	30	1/16–1/8
P. maritima	Arnold Arboretum	140	48	34	1/16–1/8
P. dasycarpa	Arnold Arboretum	130	55	42	1/16–1/2
P. Mitis	Arnold Arboretum	60	32	53	1/16–1/8
P. cerasifera	Arnold Arboretum	110	70	63	1/16–1/4
P. Munsoniana	Arnold Arboretum	70	48	68	1/8–3/16
P. Munsoniana	Arkansas	90	70	77	1/16–3/8
P. americana	Arnold Arboretum	100	83	83	1/16–1/2
P. hortulana	Arnold Arboretum	130	108	83	1/8–3/4
P. insititia	Pendula	90	77	85	1/16–1/4
P. davidiana		110	96	88	1/8–1/4
Schinus Molle	Pepper tree	110	97	88	1/4–1½
P. triflora	Burbank	120	109	90	1/2–1½
P. nigra	Arnold Arboretum	60	56	90	1/4–3/8
P. orthosepala	Arnold Arboretum	80	72	90	1/16–1/8
P. Mume	Arnold Arboretum	100	91	91	1/4–1/2
P. Munsoniana	Pits Arnold "	140	130	92	1/16–1½
P. cerasifera	P. divaricata	100	94	94	1/8–1/4
P. persica	Elberta	130	122	94	1/4–1/4
P. armenica	Royal Apricot	120	117	97	1/4–1
P. triflora	Arnold Arboretum	140	137	97	1/8–3/4
P. Munsoniana	El Paso	100	97	97	1/4–1/2
P. cerasifera	Sprouts	120	117	97	1/4–1½
P. triflora × P. Simonii	Wickson (hybrid)	140	138	98	1/8–3/4
P. cerasifera	Tree	150	150	100	1/4–1½
P. monticola	Arizona Experiment Station	40	40	100	1/2–1½
P. Simonii	Arnold Arboretum	130	130	100	1/4–1½

* The number of inoculations divided by ten is the number of separate experiments made with the various hosts.

† *Prunus Amygdalus* was not growing well during the last part of the season and no infections showed after that of July 6. Before this time a large percentage of the inoculations were positive. This will be repeated another year.

although the several varieties as Elberta, Saucer or Peento, Salway, Lovell and Muir seedlings, did not show resistance.

Fourteen different varieties of almond seedlings growing at the University Farm at Davis, California, were inoculated in 1913, and in all cases developed a high percentage of galls. So far, none of the almonds or peaches have shown marked resistance.

Prunus cerasifera, var. *Planteriensis*, Table V, is described as a double-flowering shrub and its resistance should again be confirmed. The trees from the Arnold Arboretum are on peach roots and show a more shrub-like growth than does the larger imported French tree. The slower growth may in some degree account for the smaller percentage of successful inoculations, although the general growth and characteristics of the Arnold Arboretum tree would suggest that it is probably much nearer to the wild type.

Prunus hortulana, variety Golden Beauty, Table III, is the most resistant of this species thus far tested. It is of interest to remember that this variety is supposed to have originated in western Texas, which is far outside of the limits usually given for this genus.

Of the resistant species of Prunus thus far observed, *Prunus pumila* and the two varieties of *P. domestica*, German prune and Italian (Fellenberg) prune, are the most promising. *Prunus pumila* is a shrub and while easy to grow from pits or cuttings, would be likely to dwarf the varieties of stone fruits grafted upon it. The two varieties of *P. domestica* named above, should be well adapted for other varieties of this genus, and possibly some of the Japanese types of plums. Domestica stock is used to a limited extent by some nurserymen in California and apparently has given satisfactory trees. In this instance the stock was grown from sprouts which would give a root likely to produce suckers.

The apricot is commonly used in California as a rootstock, especially for apricots. Pits of the Royal variety being easily obtained are for the most part planted. The following four species have been tested: *P. armeniaca*, different varieties, *P. armeniaca* var. *mikado*, *P. mume*, *P. mandschurica*. The tests of these species can be readily compared in Table V, with the exception of *P. mandschurica*, which was tested during 1915 for the first time. Ten puncture inoculations were made on this host at three different dates. At the close of the growing season, no galls of large size have developed, although the grafts have grown 4 to 5 feet in length. The positive infections are 60 per cent and show as small points or knobs about $\frac{1}{16}$ of an inch in diameter. This size is in marked contrast with the large galls that usually develop on apricot from artificial inoculation. Ten different commercial varieties of California apricots belonging to *P. armeniaca*, were given a preliminary inoculation test during 1915 and showed

65 to 95 per cent infection. *P. armeniaca* var. *mikado* for 1915 showed only 22 per cent successful inoculations, the galls formed being $\frac{1}{16}$ to $\frac{1}{4}$ inch in diameter.

The Damsons, *P. americana* and *P. hortulana*, have never been used to any extent in California, although more popular in other sections of the country. *P. americana* and *P. hortulana* would be well adapted for native species of plums which are not much grown in California.

It will be noted that our most popular stock, Myrobolan, peach, apricot and almond, are very susceptible to crown gall. These data, however, only go to confirm field observations, that all the different stocks used for stone fruit are often badly infested with the disease.

From the work thus far done, no definite recommendations can be made as to the use of resistant stock, although seedlings of German prune and the Italian (Fellenberg) prune should be well adapted as a stock for members of the group Domestica.

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EXPLANATION OF PLATE VI

FIG. 1. Represents galls produced artificially on a resistant stock, German prune, *Prunus domestica*. Inoculated June 29, 1914. Photograph made June, 1915.

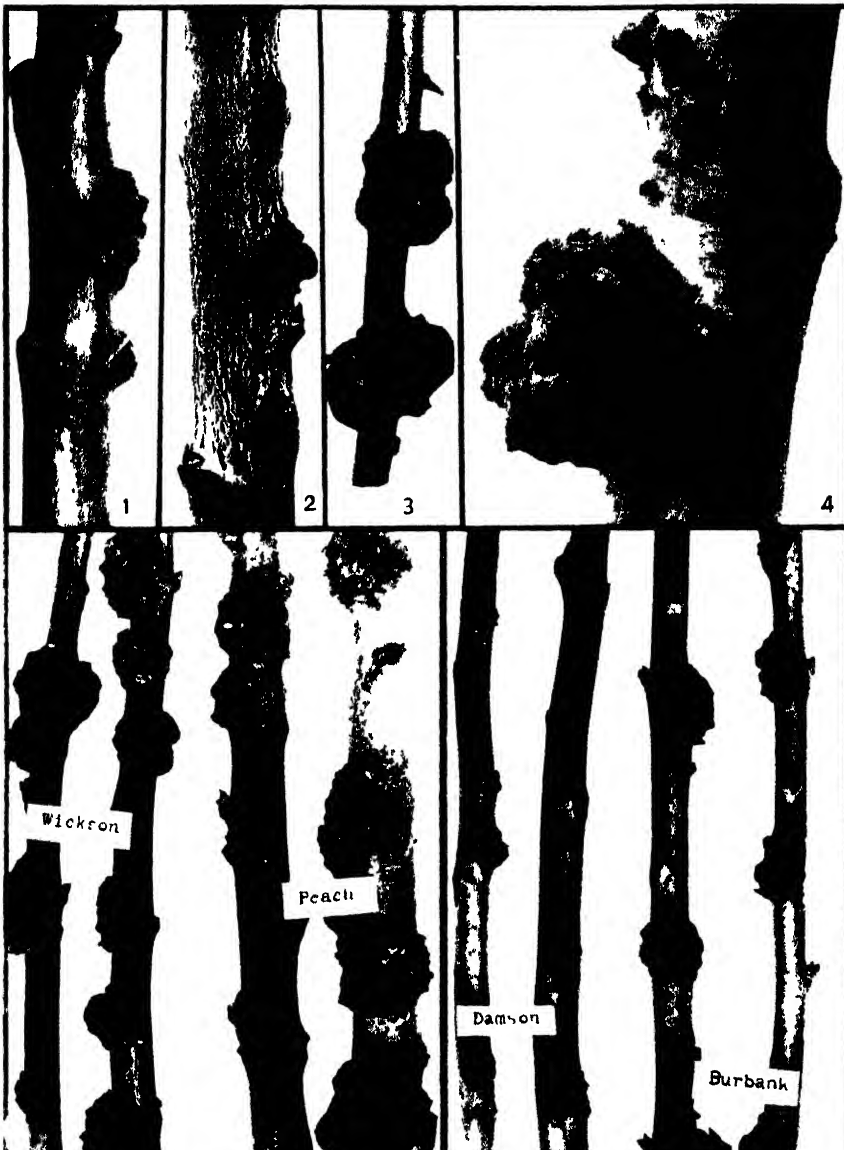
FIG. 2. Shows artificial galls on Italian prune (Fellenberg), *Prunus domestica*. Inoculated July 25, 1913. Photograph made December, 1913. Figures 4, 5 and 6 show galls on other hosts made at the same time with same culture as part of same experiment.

FIG 3 Myrobolan plum, *Prunus cerasifera*. Inoculated July 13, 1914. Photograph made September 15, 1915. Shows rapidity of gall growth on susceptible stock.

FIG. 4 Same experiment as is illustrated in figure 2, and probably the same galls as are there figured. Photographs made September, 1915, to show manner in which galls usually develop on resistant stock. Note that they are growing out almost at right angles to host, without surrounding the branch to any great extent. A comparison of figures 2 and 4, will also show the rapidity of growth of this stock during the time of the experiment.

FIG. 5 Elberta peach, *P. persica*, and Wickson plum, hybrid of *P. Simonii* and *P. triflora*. Same experiment as is shown in figures 2, 4 and 6. Illustrates two susceptible varieties and the relative size of gall as compared with the others of this experiment.

FIG. 6. Damson plum, *P. insititia*, and Burbank plum, *P. triflora*, to show relative size of galls as compared with those in figures 2, 4 and 5. Note galls on Damson stock are smaller and in some cases have not developed. This stock is resistant.



SMITH: RESISTANCE TO CROWN GALL

Materialy po Mikologii i Fitopatologii Rossii. God. I, No. 1–3. Petrograd, 1915. Redactor A. A. Jaczewski. Izd. Depart. Zemled. (Journal of Mycology and Phytopathology of Russia, Vol. I, Nos. 1–3, Petrograd, 1915. Edited by A. A. Jaczewski. Published by the Department of Agriculture.)

Russian workers in the field of plant diseases may be congratulated upon the birth of a new periodical devoted to purely mycological and pathological matters. The need for such a journal has been felt very deeply in Russia in the last few years, as the result of a rapid growth of research along these lines, especially since the establishment of the Provincial Agricultural Experiment Stations in 1913. The first three numbers of "Materialy" already have been distributed and contain original articles, reviews, notes and chronicle. It is also the aim of the editor to include later on such of the Bureau correspondence as may be of general interest to all readers.

The necessity of a thorough mycological survey of various districts of the Empire, as an indispensable condition of success in the work of plant protection, is fully recognized. Results of such surveys are published in every number of "Materialy." Along with fungi of a more or less general occurrence a number of new species have been reported. Some of these appear to be of considerable interest and economic importance. It will suffice to mention *Uromyces alhaginis* and *Septoria alhaginis* from *Alhagi camelorum* (No. 1), *Pyrenochaeta elodeae* from *Elodea densa* (No. 2), a new species of Helminthosporium discovered by Jaczewski growing in the laboratory upon a mud cone of a locust (No. 2), *Rhodosticta onobrychidis* from esparcet (No. 3), *Cercosporella lini* from *Linum nervosum* (No. 3), *Exobasidium Citri* from young fruits of mandarin (No. 3).

According to the reports of the editor, the personnel of the Bureau is very actively engaged in research work on plant diseases. Certain definite conclusions have been reached regarding control measures for club-root of cabbage and American gooseberry mildew, as well as the cause and prevention of a peculiar disease of grains known as "drunk bread," possibly due to species of Fusarium. Results of testing various fungicides are much in favor of lime-sulphur compounds as substitutes for bordeaux and other copper-salts mixtures. Work on fungous diseases of insects, on rust-resistant varieties of grains, and on certain other problems is still under way.

The Bureau has a considerable number of pure cultures and duplicate herbarium specimens, including those described by Russian scientists as new species, and they are offered for exchange with other institutions. Partial lists of these cultures and specimens are given in Nos. 1 and 2, and the additional ones will appear in subsequent numbers of the Journal.

The chronicle gives an account of various events related to phytopathology in Russia, such as notable publications, meetings, etc.

Reviews are divided in two sections: one deals with Russian literature; the other, with foreign publications.

The editorial of the first number contains a statement that this new journal "will be sent free, on an exchange basis, to all mycological laboratories and to the Russian specialists." The importance of closer international relations in phytopathology is now fully recognized, and it is hoped that the respective American institutions will accept the above offer of the Bureau of Mycology of Russia—the country which, to a large extent, has been "terra incognita" for many foreigners.

MICHAEL SHAPOVALOV

The Journal of Plant Protection (Byôchû-gai Zasshi). Published by the Nippon Plant Protection Society. (Nippon Shokubutsu Aigo-kwai.)

The importance of a knowledge of plant pathology and applied entomology for farmers and amateur plant growers, in order to avoid the damage caused by fungi and insects, was gradually recognized among the educated class of Japanese people especially interested in plants, who at last assembled together and organized a society for the purpose of explaining the importance of "plant protection" to the people of Japan and to increase special knowledge concerning the enemies of plants among themselves.

The society was founded in Tôkyô at the beginning of 1914, by 66 members, most of them belonging to the higher ranks of professional and amateur horticulturists, including Count Ôkuma and many others, with the cooperation of the government pathologists of the Plant Quarantine Station as well as the Central Agricultural Experiment Station. The business is actually carried on by eleven specialists, whose principal work is to visit the houses of full members, at least once a month, to inspect for diseases and to give any advice about the care of the plants, whether planted in gardens or in pots in dwarf form.

The present journal began publication in October, 1914, and now appears as a monthly publication, of regular octavo size, comprising about ninety to one hundred pages in each number, with photographic plates and illustrations in the text. The contents are commonly classified into

five or more groups, such as original articles, reviews of foreign papers, summaries of the results of pathological and entomological experiments conducted by central or provincial agricultural experiment stations of Japan, miscellaneous information, questions and answers, and the reports of the Society matters, and so forth. Most of the original articles seem to have been written in rather a popular style and not in a strictly scientific manner. . Still, in some cases, new fungi or bacteria are described in detail. The following are some of the more important phytopathological papers that have appeared in this Journal up to the end of 1915:

(1) BOKURA, U. On the bacteriosis of the mulberry tree. Vol. 1 (1914), pp 29-31; 149 154

(2) FUZIKURO, Y. Important diseases of ornamental plants in Formosa. Vol 2 (1915), pp. 321-323; 406 409

(3) HARA, K On the diseases of certain plants caused by parasitic fungi belonging to the Coccoideaceae Vol. 1 (1914), pp. 44 48; 267-270; Vol 2 (1915), pp. 324-328.

(4) HARA, K. A new disease of rice (Sclerotinia phyllacoloides Hara sp. nov) Vol. 2 (1915), pp. 948 949.

(5) HORI, S. A serious disease of tea caused by a new bacterium, Bacillus Theae Hori and Bokura sp nov Vol 1 (1914), pp. 247 252; Vol. 2 (1915), pp. 1 7.

(6) HORI, S. Contributions to the study of plant diseases. Vol. 2 (1915), pp 662 666; 745 748; 833 836; 927 932; 1015 1017 (so far as issued).

(7) ISHIYAMA, S On black spot disease of Japanese plum fruit caused by Pseudomonas pruni Sm Vol. 1 (1914), pp. 48-51; 166-171.

(8) NAKATA, K Brown rot of sugar beet in Korea with especial reference to the fungus Cercospora beticola Sacc. Vol. 2 (1915), pp. 116-122; 207-210.

(9) NAKATA, K. On the fungus causing the anthracnose of cotton. Vol. 2 (1915), pp. 309 311.

(10) TAKIMOTO, S. A preliminary report on the sclerotiosis of ginseng. Vol. 2 (1915), pp. 328 331; 422 426; 521 523.

(11) TAKIMOTO, S "Leaf burn" disease of Vicia Faba and a new bacterium, Pseudomonas Viciae Uyeda n sp as the cause of the disease. Vol. 2 (1915), pp. 846 851.

(12) TSURUDA, S Some newly found diseases of barley and wheat in the Province of Shidzuoka. Vol. 2 (1915), pp. 854 859

(13) TSURUDA, S. On a new fungus, Phyllosticta Broussonetiae Hori n. sp, of Japanese paper mulberry. Vol 2 (1915), pp. 1040 1042.

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PHYTOPATHOLOGICAL NOTES

Marking laboratory apparatus. It often becomes necessary to mark laboratory apparatus for purposes of identification. In many cases metal apparatus is seriously damaged if a hardened steel die and hammer are used. Various methods are in common use for marking such apparatus. Those which have proved the most satisfactory for our purposes in the laboratory of Forest Pathology, U. S. Department of Agriculture, Providence, R. I., are indicated below.

Iron and *steel* (not nickel-plated) can be marked by the well-known copper-sulphate method. In practice we have used a pointed toothpick and a watery solution of copper sulphate. The marker is prepared for use by thrusting one end of a wooden toothpick into the small end of a cork which fits a small vial. The other end of the toothpick is pointed, while around it just back of the point a small amount of absorbent cotton is wrapped. In the vial is placed a sufficient quantity of copper-sulphate solution to wet the cotton when the cork is in place. The marking is done by removing the cork with the attached toothpick and tracing the required letters or numbers on the steel or iron with the wet point of the toothpick, in much the manner that a pen would be used for a similar purpose. The surface to be marked previously must have been freshly cleaned (e.g., with fine emery cloth). The cotton merely serves to lift a greater quantity of the copper solution than would be possible without it. The mark will appear as a deposit of copper, which can be intensified by a second or third application.

Glassware is permanently etched by the well-known hydrofluoric acid method. In practice we keep a small dish of melted paraffin in the water-bath and in this a small swab made of absorbent cotton or cheesecloth wrapped about one end of a small rod of wood. With the swab a thin film of paraffin is quickly smeared over the surface of the cold glass at the point where it is to be marked. This film instantly hardens. Through this, to the glass, the required legend is scratched with a dull needle or sharply-pointed pencil, and hydrofluoric acid from the rubber or wax covered bottle applied with another swab of cotton similar to the one mentioned above, taking care that the acid does not come in contact with the fingers. An application of a few minutes is usually sufficient and the acid can then be washed off with water. If the glassware will stand a stream of hot water, this will be the most convenient method of quickly and cleanly

removing the paraffin; otherwise it may be partially removed by scraping, and finally cleaned with a piece of cloth wet with any one of the well-known solvents of paraffin. In the quiet air of a laboratory it often happens that the heavy acid fumes slowly spread beyond the area of paraffin and cause a fogging of the glass. This is overcome by setting the apparatus in a draught of air during the time the acid is acting, or better by covering a much larger area of glass with paraffin at the outset.

Nickel plated articles, as well as iron, steel, brass, bronze, copper, German silver, and zinc, are very neatly etched in precisely the same manner as glassware, except that strong nitric acid is used instead of hydrofluoric. Care should be taken that the acid does not come in contact with the skin, and that the fumes are not inhaled.

J. FRANKLIN COLLINS

Marking trees in the field. When working in the field it is often necessary to mark trees for future positive identification, in order that successive observations may be made on the same trees. For this purpose various methods are in use by various workers.

The writer has used many different methods, of which the following have proved the most satisfactory. If it is necessary that the mark remain visible for a few months only, and the bark is not too rough, we generally use "Dixon's Yellow Lumber Crayon," and occasionally also the red or white crayons when a distinctive color is desired for special purposes. These crayons are of a waxy nature and a mark made with one of them usually lasts for some months. We have often marked trees with these crayons in August or September and the legend or number has been clearly visible the following spring.

If a more permanent and conspicuous mark is desired, white paint and a brush will be found more serviceable when many trees are to be marked. If only an occasional tree is to be marked in this manner, a more convenient method (and one which makes it unnecessary to carry a paint-pot about) is to take in the pocket a small tube of artist's oil paint of the color desired. When this is to be used the cap of the tube is unscrewed and the tube held perpendicular to and against the surface of the bark or wood. By moving the tube over the surface of the bark, and at the same time gently pinching the tube, any desired symbol or number can be painted on its surface, no brush being necessary. A very little practice will enable one to make a neat symbol that will usually last from two to five years under ordinary conditions.

Occasionally it is desirable to mark a tree in an inconspicuous yet definite manner. For this purpose we have for years successfully used long copper tacks with heads about one-quarter inch broad, upon which dis-

tinctive numbers have been stamped with steel dies. By beginning with No. 1 in each new locality it is rarely necessary to use more than two figures on a tack. In practice the tacks are usually placed at a certain uniform height on each tree and the height and orientation of each recorded. This makes it comparatively easy to find the tack at a later date. In the course of two or three years the tack may become entirely overgrown by the newly formed bark and wood. If the position on the tree has been carefully recorded, it is not a difficult matter to find the small depression which indicates the position of the tack, and a little cutting with a knife will reveal the number. When a tree is susceptible to a specially virulent parasitic disease (e.g., the chestnut bark disease), or when for other reasons it becomes necessary to take extra precautions against infection at the point where the tack would be driven into the tree, some other method may have to be used.

J. FRANKLIN COLLINS

Cutting and trimming small blocks of wood. For cutting small pieces of wood, twigs, and so forth, into still smaller blocks preparatory to embedding, preserving, or dehydrating, or for any other purpose where it is necessary to have the material trimmed or cut without crushing any of the tissues adjoining the cut, we have found no instrument superior to the fine-toothed fret-saw. To many people this saw may be better known as a bracket-, scroll-, jig-, or puzzle-saw, and is almost universally used to make perforated brackets and zig-zag puzzles. The foot power saw is undoubtedly the best for many purposes, although personally we have rarely used it, as we prefer to use the hand saw of the type used by jewelers in sawing out intricate designs in sheet metal.

When the hand fret-saw is used it will require a little practice to hold the material sufficiently rigid to saw it easily and prevent breaking the saw. This difficulty is largely overcome by using a supporting strip of soft wood, seven-eighths of an inch thick by two or three inches wide, and six or eight inches long, one end of which is screwed or clamped firmly to a table or bench. The other end projects beyond the edge of the table for three or four inches. The under side of this strip of wood is beveled backward for a distance of two inches so that the projecting end of the strip is not over one-eighth of an inch thick.

When small blocks, or those specially difficult to hold, are being cut, the operation is generally simplified by holding the block endwise between the thumb and first finger and pressing it down firmly on top of the beveled strip of soft wood (at the thin edge), and at the same time sawing into the edge of the soft wood a sufficient distance to cut through the block without moving the latter.

In using the hand-type of saw it is usually best to hold it nearly vertical, with the handle below the support or bench. The saw should be fastened into the saw-frame so that the cut will be made on the downward stroke.

J. FRANKLIN COLLINS

Polishing sections of wood. Blocks or cross-sections of healthy or decayed wood which are to be used for exhibition purposes or for photographing can readily be smoothed and polished in such manner as to show the grain very clearly by the following method. A fine-toothed hand-saw (or even a circular saw) of the usual type is used to cut the wood at the points desired. The surface to be polished is then held against a flat, rapidly rotating, sandpaper disk. The disk used by cabinet-makers is often made of wood with the sandpaper glued to its surface.

For my own use I have had constructed a flat-faced, circular, iron disk, nine inches in diameter, which gives a much finer grade of polished surface than the wooden disk. The sandpaper is cut into nine-inch squares. The projecting corners are turned back over the edge of the disk and there held firmly in place by heavy spring clips. This arrangement allows the sheet of sandpaper to be easily and quickly removed and a finer or coarser grade substituted whenever desired. The disk is placed on the shaft of an ordinary turning-lathe, but could easily be adapted to be attached to almost any type of motor.

The final polishing is done with the finer grades of sandpaper. For best results the block of wood must not be held against the rapidly rotating disk sufficiently long at any one time to cause scorching and consequent discoloration of the wood.

J. FRANKLIN COLLINS

Sclerotium Rolfsii in Illinois. During the summer of 1915 a number of the prostrate plants in the perennial garden of the Floricultural Division of the University of Illinois were found dying from a crown-rot. A study of the diseased material showed that the rot was caused by *Sclerotium Rolfsii* Sacc. This is the first report of the occurrence of this fungus in Illinois and the first account of this fungus causing a serious disease of the cultivated perennials.

The symptoms of this disease are similar to those described by Rolfs and others in the South. In all plants examined the fungus produced a typical crown-rot, and in many cases where the leaves and branches touched the soil, a rotting of these parts ensued.

The fungus is characterized by a white, rather straight, mycelium, which spreads out in strands on the under side of the plant, in a fan-shaped

or radial manner. On the surface of this mycelium large numbers of smooth and usually spherical sclerotia, which are at first white, yellow, and finally dark brown, develop. The sclerotia resemble radish or mustard seeds. From the size of the sclerotia in the field and those obtained in culture, it appears that they are somewhat larger than the sclerotia found in the South. Saccardo, in describing the species, gives 0.5 to 0.8 mm. for the diameter of the sclerotia, while Smith reports the following measurements, 0.8 to 0.9 by 1.2 to 1.3 mm. The sclerotia found in the perennial garden measure 0.8 to 3 mm. in diameter, while those on potato plugs may reach a diameter of 5 mm.

The disease first appeared in July and a number of plants were killed during the warmer weather. However, it persisted until the last of October, although its attacks were less severe, only a few branches of the plants being killed. The disease appeared in various parts of the garden and its spread from plant to plant could be clearly followed.

The writer has found the fungus growing on and killing the following perennials: *Campanula medium*, *C. persicifolia*, *C. carpatica*, *C. nobilis*, *Erigeron glabellus*, *Dianthus plumarius*, *Dracocephalum arganese*, *Penstemon pubescens*, *P. murrayanus*, *Phlox subulata*, and *Eupatorium ageratoides*. Of these plants, the Campanulas appear to be the most susceptible, the species *C. medium* being particularly so.

The severity of the disease was, no doubt, influenced by the extremely wet summer, when 29 inches of rain fell between March 1 and October 1, 1915. During the month of July, when the disease was at its height, the rainfall was 7.3 inches. The temperature which prevailed during the summer was rather low as compared with that of the two previous summers. July was the warmest month, with an average temperature of 74° F. It appears that at least two factors are necessary for the growth of this fungus, an abundance of moisture and a soil temperature above 60° F.

GEO. L. PELTIER

A note on Cronartium pyriforme. In looking over the literature on the aecial stage of *Cronartium pyriforme* (Peck) Hedgc. and Long on pines, I can find few definite data in regard to the size of the trees infected or the height at which infections occur. Orton and Adams[1] in reporting *Cronartium* (*Peridermium*) *pyriforme* on *Pinus pungens* state, "One of the striking features of this rust was that in every case but one, of a dozen or more which were seen, the infection was upon the trunks of the young trees

[1]Orton, C. R., and Adams, J. F. Notes on Peridermium from Pennsylvania. Phytopath. 4: 23–26. 1914.

very close to the ground. In the one exception it was upon the lowest branch but not more than 6 inches above the ground." Hedgcock[2] reports the occurrence of the parasite only on small saplings of *Pinus pungens* and *Pinus ponderosa*. Hedgcock and Long[3] give the area of infection as varying from an inch to more than one foot in length on young lodgepole pines and western yellow pines. My former observations[4] on this rust on *Pinus ponderosa* show the largest infected tree to have a diameter of 8 inches at breast height. On another tree the infection occurred 5 feet from the ground. The areas of infection, varying from 2 inches to a foot in length, were usually found on the main stem but occasionally on the branches.

In the spring of 1915 a specimen of this rust on *Pinus ponderosa* presenting some unusual features was sent to the laboratory of Forest Pathology, U. S. Department of Agriculture, San Francisco, Calif., from a forest in the Coast Range of California. According to information from the field, the infection began at a height of 35 feet from the base of the tree, extending up the trunk for a distance of 3 feet, including a branch whorl and running into the base of the limbs. The entire top of the tree above the place of infection was dead, as were also the infected limbs of the branch whorl. The tree was about forty years old at stump height and had a diameter of 14 inches at breast height.

Upon examination of the specimen, which included the infected area on the trunk and the branch whorl, the tree trunk at the base of the infection was found to have a diameter of $7\frac{1}{2}$ inches and to show 14 annual rings. A very slight spindle-shaped swelling had extended over the entire area of infection. The aecia were sporulating abundantly, both on the trunk and branches. The color of the spore powder, three days after collection, was a very slight degree lighter than Cadmium Orange.[5]

The thickness of the dead bark under which the aecial sori developed was remarkable. One sorus, 5 mm. wide by 1.5 mm. deep, was completely covered by a bark scale 6 mm. thick. A second one was found well covered by a bark scale 7 mm. thick.

The specimen was collected in Trinity County, California, at an elevation of 2200 feet.

J. S. BOYCE

[2]Hedgcock, George G., and Long, William H. A disease of pines caused by Cronartium pyriforme. U. S. Dept. Agr. Bul. 247: 14. 1915.

[3]Loc. cit., p. 13.

[4]Quoted by Hedgcock and Long. Loc. cit., pp. 14 and 15.

[5]Ridgway, Robert. Color standards and color nomenclature, Plate III.

Pan-American Scientific Congress. The following resolution in regard to plant protection was adopted by the Congress at its final session in Washington, January 8, 1916:

"XIII. That an American plant-protection conference be convened, the delegates thereof to be one or more technical experts from each of the several American countries, and that as soon as practicable a meeting of this conference be held to discuss suitable legislation, the means of establishing competent scientific bureaus, and to recommend such cooperative research work and control of plant introduction as may be advisable, and to use all reasonable efforts to secure appropriate action by the several countries."

A committee, consisting of C. L. Marlatt, D. G. Fairchild, and C. L. Shear, of Washington, D. C.; John R. Johnston, of Cuba; C. D. Andrade, of Ecuador; E. Carasco, of Chile; and Roberto Sundberg, of Uraguay, was appointed by the Chairman of Section III as a temporary committee to assist in promoting the purposes of the resolution.

Kew Pathological Laboratory. A laboratory for the exclusive investigation of problems in plant pathology has been equipped at the Royal Botanic Gardens, Kew, England, and work is now in progress. The laboratory has been formed by the alteration of two Georgian cottages facing Kew Green. Mr. A. D. Cotton, formerly of the Cryptogamic Herbarium at Kew is assistant, first-class, in the plant pathology laboratory and is now in active charge of the work. He will devote his entire time to plant pathology. William Broadhurst Brierley, M.Sc., of the University of Manchester, has also been appointed a first-class assistant in the laboratory.

Recovery of a chestnut tree from a lightning stroke. Lightning injury to trees of various species is a matter of common observation. Sometimes trees are killed outright without being shattered or externally wounded. More often, however, the stroke causes a more or less severe shattering of the tissues, which may be accompanied by the death of the tree or by no apparent injury beyond the wound itself. In many cases neither death nor important mechanical injury results.

An instance of lightning injury to a chestnut tree, *Castanea dentata*, which differs in some respects from any recorded in available literature and seems of sufficient interest to warrant publication, has recently come under the writer's observation. The chestnut referred to is situated about one mile above Van Bibber, Maryland, on the south side of the Baltimore & Ohio track and not far from the railroad's right of way, a short distance below Bush River station. The tree has two trunks of nearly equal size

(14 to 16 inches, diameter, breast high) joined for only a few inches above the surface of the ground. One trunk slants slightly to the south, the other to the north.

This tree was first seen by the writer April 28, 1914, and at once attracted attention, because both halves retained apparently all the burs of the previous season's crop. Single branches or small trees killed by the chestnut blight when the nuts are partly mature characteristically retain their burs as well as leaves for a year or more; in fact, this has come to be regarded as a "signal" of the possible presence of the disease. The writer had never before seen a large chestnut with burs on all its branches and it seemed as if the tree must have been girdled near its base so quickly as to kill both trunks during a single season.

Examination showed, however, that the tree had been struck by lightning. The southern trunk bore on the side farthest from the north trunk a characteristic lightning groove from two to four inches wide which reached nearly the length of the tree. The north trunk showed no scar whatever but had apparently been killed by the shock. Neither trunk showed any evidence of infection with *Endothia parasitica*. Under date of April 28, 1914, the writer made the following entry in his field notebook, "A large double chestnut struck by lightning holding burs as though diseased [by *Endothia parasitica*]." During the summer of 1914 the locality was visited about once a month in connection with other work on the chestnut; beginning with July 6, the tree was used as a marker for locating inoculations and on this date the following directions were entered on the notebook, "Follow up track to third cut, cross fence by dead tree with burs." August 10, 1914, the tree appears on the sketch map labeled "Double dead chestnut with burs." October 6, 1914, it appears on the sketch map as "Double lightning-killed tree." The tree was also observed on May 31 and December 30, 1914. About the middle of the summer numerous water-sprouts appeared at the base of the tree on the northwest side. This was the only indication that the tree had not been killed outright. On May 14, 1915, no change was noted except that a few of the burs had fallen.

The locality was not visited again until October 7, 1915, when the northern half, the one which had not been scarred by the lightning, was found to be in apparently full foliage and to have a few nearly mature burs. The half which had been actually struck by lightning, that is, bore the lightning scar, was quite dead and not only the dead burs but small branches were falling. The northern half showed several branches affected with the chestnut blight. Two branches had apparently been girdled early in the summer before the leaves had attained full size, as they still bore the partly developed leaves.

If the data presented above are correct, and in view of the frequency with which the locality was visited and the notes made, this seems certain, the tree was struck by lightning late in the summer of 1913, that is, when the burs were practically full size. It showed no signs of growth except the small water-sprouts at the base of the tree until the spring of 1915. At this time the buds formed more than eighteen months earlier developed on the unscarred half of the tree.

Two explanations of this peculiar phenomenon have been suggested to the writer. One is that the failure of the north half to leaf out in 1914 was due to the killing of its root hairs and small roots by the current passing through the ground, and that the buds and the cambium layers of the larger roots and trunk although uninjured did not begin growth until the root hairs had been regenerated in sufficient number to furnish them with water, that is, not until the spring of 1915. The failure of the tree to regenerate root hairs and to leaf out late in the summer of 1914 might readily be explained by the extreme drought of that season.

A quite different explanation is that the tree suffered from a severe shock, or partial electrolysis of the protoplasm, which permitted some activity during 1914, sufficient for the formation of water-sprouts, but, in conjunction with the severe drought, not sufficient for the development of the buds. While it is impossible to demonstrate which, if either, of these hypotheses is correct, they are suggestive explanations of the known facts.

NEIL E. STEVENS

Sulfur paste as a spray for peaches. The unusual losses in 1915 sustained by peach growers in many sections on account of brown rot (caused by *Sclerotinia cinerea*) and of scab (caused by *Cladosporium carpophilum*) have stimulated much inquiry in the agricultural press and in fruit growers meetings about summer spraying to prevent these diseases. At a recent meeting of the Western New York Horticultural Society, a grower of peaches commended to fellow growers the use of a sulfur paste instead of the Scott lime-sulfur mixture. His claim was that the paste was more easily prepared than the Scott mixture and that it could be used up until the day of picking without serious objection from spotting the fruit.

The writer has had considerable experience in preparing the paste and can vouch for the ease of preparation and for the excellent manner in which the suspension passes through a spraying machine

A description of the preparation[1] of the paste has been published by Reddick and Crosby[2] but as this was incidental to an experiment with apples, repetition seems desirable. Arsenate of lead may be used or omitted as desired.

The exact method of preparation as used in this experiment is as follows: 2½ ounces of pulverized glue was dissolved in 2½ to 3 gallons of warm water; 20 pounds of the finely ground sulfur and 2 pounds of powdered arsenate of lead were weighed out into a large pail or other convenient receptacle Glue solution was added as required, and was worked into the mixture by kneading with the hands. This required about five minutes. After the mixture was thoroughly wetted, it was thinned about one-half with water and poured into the strainer of the spray tank. The strainer consisted of a wooden box with a bottom of copper gauze, 20 meshes to the inch, supported by heavier galvanized gauze, 4 meshes to the inch. By turning the flow of water from the filling apparatus into the mixture, it was easily worked through the gauze with the hands or a brush

DONALD REDDICK

Personals. Dr. J. J. Taubenhaus, associate plant pathologist of the Delaware Agricultural Experiment Station, recently accepted the position of head plant pathologist and physiologist of the Texas Agricultural Experiment Station. His new address after February 20 will be College Station, Texas. Prof. F. H. Blodgett, the former incumbent, is to engage in extension work in plant pathology.

Mr. George Massee has retired from the Cryptogamic Herbarium at Kew and Miss Elsie M. Wakefield is now in charge.

Dr. L. O. Kunkel, of the Bureau of Plant Industry, who is abroad for a year under a traveling fellowship from Columbia University, is located for the winter with Dr. Friedrich Oltmanns, at Freiburg in Breisgau, Germany.

Dr. H. W. Wollenweber continues work on his Fusarium Monograph at the Kaiserliche Biologische Anstalt, Dahlem-Berlin.

Notice. Attention is called to the action of the Society at the Columbus meeting in directing the publishers and the Business Manager to raise the price of back volumes of PHYTOPATHOLOGY on July first from $4 to $5 per volume. Separate copies will not be sold except in cases where the volumes are already broken, and the price of such copies will be 85 cents each.

[1] This method of wetting sulfur has been known to sulfur chemists for many years.

[2] Cornell Univ. Agr. Exp. Sta. Bul. 354: 82. 1915.

Notice. The fifty subscribers necessary to undertake the publication of the card index to Pan-American phytopathological literature have not yet been secured. As it is desirable to make arrangements for the publication of the cards as soon as practicable, we beg to urge that each member of the Society who is connected with an institution supporting a library make a special effort to secure a subscription from the librarian and have it forwarded to the Secretary. Please do not delay, but do it now.

L. R. JONES
C. L. SHEAR
R. A. HARPER

REPORT OF THE SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The seventh annual meeting of the Society was held in the Botany and Zoology Building of the University of Ohio, Columbus, Ohio, December 28–31, in conjunction with the American Association for the Advancement of Science.

About fifty members were present and a program of sixty-eight papers was presented. The abstracts appeared in the last number of PHYTOPATHOLOGY. Twenty-five new members were elected, making a total of three hundred and thirty-five.

Joint sessions were held with Section G of the American Association for the Advancement of Science and with the Botanical Society of America.

The following officers were elected:

President, Dr. Erwin F. Smith, U. S. Department of Agriculture, Washington, D. C.

Vice President, Dr. Mel. T. Cook, New Jersey Agricultural Experiment Station, New Brunswick, N. J.

Secretary-Treasurer for three years, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

Councilor for three years, Dr. F. D. Kern, Pennsylvania State College, State College, Pa.

Councilor for one year, Dr. E. C. Stakman, College of Agriculture of the University of Minnesota, St. Paul, Minn , to fill the unexpired term of Dr. Mel. T. Cook

One of the Chief Editors of PHYTOPATHOLOGY for three years, Dr. W. A. Orton, U. S. Department of Agriculture, Washington, D. C.

Associate Editors, Prof. H. T. Güssow, Central Experimental Farm, Ottawa, Canada; Dr. C. W. Edgerton, State Experiment Station, Baton Rouge, La.; Dr. E. C. Stakman, University Farm, Saint Paul, Minn.; and Dr. V. B. Stewart, Cornell University, Ithaca, N. Y.

Business Manager of PHYTOPATHOLOGY, Dr. C. L. Shear

The Society decided to hold its next annual meeting in New York City December 26–30, 1916, in conjunction with the American Association for the Advancement of Science.

INCORPORATION OF THE SOCIETY

In accordance with instructions from the Society at its Philadelphia meeting, the Secretary secured the two other members required, Dr. W. A. Orton and Dr. Neil E. Stevens, and took out articles of incorporation for the Society under the laws of the District of Columbia. These articles are as follows:

Articles of Incorporation

City of Washington, District of Columbia:

We, the undersigned,

C. L. Shear, Vienna, Va.
W. A. Orton, Washington, D. C.
N. E. Stevens, Washington, D. C.

being persons of full age, and citizens of the United States and a majority being citizens of the District of Columbia, pursuant to and in conformity with Sections 599–604 of the Code of Law for the District of Columbia, enacted by the Senate and House of Representatives of the United States of America in Congress assembled, and approved March 3, 1901, hereby associate ourselves together as a body corporate, and certify in writing:

1. That the name of the body corporate is The American Phytopathological Society.

2. That the term for which the Society is organized is perpetual.

3. That the particular business and objects of the Society are to promote investigation and advancement in plant pathology and cooperation among plant pathologists, to hold meetings for the presentation and discussion of the results of research and investigation, to exchange ideas and experiences and consider methods and means of promoting research, to stimulate and encourage the members, to cooperate in all practical ways with other scientific organizations and agencies for the advancement of science and to publish and encourage the publication of contributions to plant pathology.

4. That the affairs, funds and property of the Society shall be in charge of a council of seven members: the President, Vice President, Secretary-Treasurer, retiring President, Chief Editor of PHYTOPATHOLOGY, and two members, one elected each year.

WITNESS our hands and seals, October 25, 1915

Witness:
CHARLES BROOKS,
as to all.

C. L. SHEAR (*Seal*)
W. A. ORTON (*Seal*)
N. E. STEVENS (*Seal*)

DISTRICT OF COLUMBIA, SS:—

I, W. Spencer Armstrong, a Notary Public in and for said District, do hereby certify that C. L. Shear, W. A. Orton, and N. E. Stevens, parties to, and personally well known to me to be the persons who executed the annexed Articles of Incorporation, dated October 25, 1915, personally appeared before me in said District and acknowledged the same to be their act and deed.

TAKEN and certified by me under my hand and Notarial Seal this 25th day of October, 1915.

W. SPENCER ARMSTRONG,
Notary Public, D. C.

(10c. Int. Rev. Stamp affixed)
(*Notarial Seal*)

OFFICE OF THE RECORDER OF DEEDS,
District of Columbia.

This is to Certify that the foregoing is a true and verified copy of the Articles of Incorporation of The American Phytopathological Society and the whole of said Articles of Incorporation as filed in this Office, the 25th day of October, A. D. 1915.

In TESTIMONY WHEREOF, I have hereunto set my hand and affixed the seal of this Office this 25th day of October, A. D. 1915.

R. W. DUTTON,
Recorder of Deeds, D. C.

(10c. Int. Rev. Stamp affixed)
{*Recorder of Deeds*
District of Columbia}

Minutes of Meeting of Incorporators of the American Phytopathological Society

A meeting of Messrs. Shear, Orton, and Stevens, signers of articles of incorporation of The American Phytopathological Society, Incorporated, was held in Washington, D. C., October 25, 1915.

A temporary organization was effected, with W. A. Orton, Chairman, and C. L. Shear, Secretary.

The constitution and by-laws of The American Phytopathological Society as now standing were adopted.

Present members of the Society were elected members of the corporation, with their present rights and privileges.

The meeting adjourned to assemble at Columbus, Ohio, December 28, 1915.

C. L. SHEAR,
Secretary

REPORT OF COMMITTEES

The Committee on Common Names of Plant Diseases, consisting of F. C. Stewart, G. P. Clinton, F. L. Stevens, and E. M. Freeman presented the following report and the rules for the preparation of a list of common names:

After careful consideration of the various suggestions and criticisms submitted by members of the Society the Committee on Common Names recommends that the following rules be observed in the preparation of a list of the common names of plant diseases:

1. Names already in wide use shall not be changed except for urgent reasons.
2. As far as possible the name used shall be one which is descriptive of the characteristic symptoms produced in the host
3. Diseases not coming under Rule 1 or Rule 2 may be named after the causal organism; examples Rhizoctoniose, Armillaria root-rot; but long, clumsy names should be avoided.
4. In general the various diseases caused by an organism on its different hosts shall bear the same common name, but this rule shall give precedence to Rule 1 and sometimes also to Rule 2.
5. An attempt shall be made to provide common names for all common and important diseases of the principal cultivated plants in the United States and Canada.
6. In addition to fungous and bacterial diseases, the list may include non-parasitic diseases and those of unknown origin, but not diseases caused by insects or animals.
7. Names of diseases caused by fungi and bacteria shall be followed in the list by the Latin name of the causal organism, non-parasitic diseases by "non-par.," and diseases of unknown origin by "undet." The name of each disease shall be followed by one or more bibliographic references which shall be selected with regard to—
   (a) Accuracy and completeness of the description.
   (b) Accessibility of the publication.
   (c) Priority of publication.
   (d) Language, American references being given preference.
8. The order of arrangement of hosts and of diseases under each host shall be alphabetical.
9. No common name shall be adopted unless approved by all five members of the Committee on Common Names.

10. From the choice of scientific names select the one which common usage and critical investigation have shown to belong to its mature stage.

It will be observed that the most important difference between this set of rules and the one submitted to the Society a year ago is found in Rule 10. It should be borne in mind that the proposed list is official only in respect to the *common* names and these only should be considered by the Society in voting on the adoption of the list. If it is deemed advisable for the Society to take official action on the *scientific* names used, a special committee should be appointed to consider the matter.

A partial list, including the diseases of hosts from alfalfa to cabbage, inclusive, is submitted herewith. Before proceeding further the Committee wishes to know whether the plan exemplified in this partial list meets with the approval of the Society. It is the sense of the Committee that the first list adopted should be considered only preliminary to a complete list to be prepared a few years hence.

The report and rules were adopted, and the Committee was directed to send to each member of the Society for criticism and suggestions the preliminary list of common names which it had prepared.

Some changes were made in the Committee, which now consists of F. C. Stewart, Chairman, G. P. Clinton, F. L. Stevens, E. C. Stakman and W. A Orton.

The Committee on Ways and Means, consisting of F. C. Stewart, C. L. Shear, D. Reddick, H. H. Whetzel, and L R. Jones, reported that they had endeavored to secure an endowment for PHYTOPATHOLOGY, but thus far without success. It is considered desirable, however, to continue efforts in this direction, which it is hoped will finally be successful.

To meet the present needs of the Journal and to provide for the immediate future the Committee recommended that as many as possible of the members agree to pledge themselves to pay one hundred dollars in annual payments of ten dollars each and thus become sustaining life members of the Society

The report of the Committee and the proposed plan were adopted, and over forty of the members present pledged themselves as sustaining life members

At its request the Committee was discharged and the following new Committee appointed: L. R. Jones, Chairman, C. L. Shear, C. W. Edgerton, H. S. Jackson, and J. T. Barrett.

The Committee on Bibliography, consisting of L. R. Jones, C. L. Shear, and R. A. Harper, reported that through the assistance of Miss Oberly, Librarian of the Bureau of Plant Industry, U. S. Department of Agriculture, estimates from Williams & Wilkins Company had been obtained as to the cost of publishing the index of Pan-American phytopathological literature in the form of a card index, with three cards for each title. It was found that if subscriptions for fifty sets could be guaranteed the following price could be obtained: Back numbers for 1914 and 1915, $26; yearly subscription for current year, $12.50. A subscription blank was sent to each member and also to various libraries, but only about twenty-five subscriptions have been received.

The report of the Committee was adopted and the Committee continued. It was suggested that as the cost of these cards is greater than most of the members would care to assume that each member who is connected with an institution maintaining a library should make a special effort to secure a subscription from the library. It is hoped that each member will take this matter up at once in order that the necessary subscriptions may be obtained and arrangements made to issue the cards as soon as possible.

The Committee on the Schweinitz Collection of Fungi, consisting of C. L. Shear, J. C. Arthur, and A. G. Johnson, reported that it had corresponded with the Curator of the Academy of Natural Sciences of Philadelphia and had been assured that the authorities would be glad to adopt such suggestions as the Committee might make in regard to the more secure protection of the Schweinitz herbarium.

The report was adopted and the Committee continued

The Committee on Bibliographical Index to North American Fungi originally consisted of Dr. Charles E. Bessey, with power to appoint associates. On Dr. Bessey's death Dr. Geo. T. Moore was requested to take charge of the matter. Doctor Moore reported that the chief reasons for the delay in the appearance of Dr Farlow's index were the great amount of time and labor required in preparing the work and the difficulties connected with synonomy and nomenclature. The report was accepted

The Committeee on Institutional Standardization, H S. Reed, Chairman, made a report of progress and asked that the Committee be continued The report was accepted and the Committee continued

The Committee on Organization and Affiliation of Branches of the Society, consisting of Haven Metcalf, C L Shear, Wm T Horne, H. S. Reed, and H. S Jackson, unanimously recommended the adoption of the following provisions for the organization and regulation of branch societies.

1 Branch societies shall elect to full membership only members of the American Phytopathological Society, but each branch society may elect associate members under such rules as it may adopt

2 Branch societies which are established on a geographical basis shall be known as Divisions, and shall use the name of the parent society with the appropriate geographical term. For example, "American Phytopathological Society Pacific Division."

3 The proceedings of Divisions shall always be printed in PHYTOPATHOLOGY The preliminary abstracts of the Division meetings may at the discretion of these Divisions be printed in PHYTOPATHOLOGY upon the same terms as the abstracts of the American Phytopathological Society, i.e , at the expense of these Divisions. This rule, however, shall not be interpreted as limiting the present right of the Editorial Board of PHYTOPATHOLOGY to define the character and amount of any manuscript presented for publication.

4 Whenever the American Phytopathological Society meets within the territory of a Division the Division shall merge its program with that of the parent Society The scientific sessions of such a meeting shall be presided over alternately by the president of the American Phytopathological Society and the president of the Division. Business sessions may be independent.

5. The constitutions or articles of organization of all Divisions shall contain a provision or provisions ratifying the above rules. The constitutions of all Divisions shall contain nothing in conflict with the constitution of the American Phytopathological Society. With the exceptions defined by the above rules the Divisions shall enjoy complete autonomy.

These rules were adopted by the Pacific Division at the Berkeley meeting of the Society.

The report of the Committee was accepted and the rules unanimously adopted by the Society.

The Committee on a Pure Culture Supply Laboratory, consisting of C. L. Shear,

L. R. Jones, and G. P. Clinton, reported that the matter had been taken up with the Chief of the Bureau of Plant Industry and various heads of offices, and that it had reason to hope that provision could be made for establishing this work, in a preliminary way at least, during the coming year.

The report was adopted and the Committee continued. Resolutions were also adopted requesting the authorities of the Department of Agriculture to give this matter favorable consideration if possible.

The Committee on Summer Meetings, consisting of Paul Murphy, E. C. Stakman, and D. Reddick, presented the following report:

The Committee, having considered the subject carefully, has come to the conclusion that summer meetings are desirable.

Two alternatives were considered, namely, in the first place, a single general gathering, and in the second place sectional gatherings of phytopathologists interested in special crops.

The Committee is of the opinion that a single general gathering is impracticable for several reasons. In the first place the distances which most members would have to travel would be too far, particularly at a time when the pressure of work is greatest. Besides it would be difficult to find an area in which there would be a sufficient variety of crops to satisfy the special requirements of all present. Further, a general meeting would naturally resolve itself into several sections, those interested in the diseases of any one group of crops having a natural tendency to segregate themselves.

The Committee is therefore of opinion that it would be more practicable for those interested in special lines, such as diseases of cereals or those of potatoes, to meet separately. It considers further, since most of the members would not have time or opportunity to travel very far, that the country should be divided into several sections which are natural units in virtue of climate, soil, geographical position or nature of crops raised. An example of such a section would be the most eastern seed-potato-raising States, including the Maritime Province of Canada. Another would be the cereal section of the upper Mississippi. The course recommended is that those interested in potato diseases in the northeastern section, for example, if they see fit, should meet at a convention place, say in Maine, all arrangements to be made by themselves of course. It is not necessary or even desirable that the number attending should be large.

The Committee considers that the gatherings should be quite informal. The only organization that would be required would be that a member, who might be called the Chairman, would invite by letter all those likely to attend, and generally supervise the arrangements. It would be desirable for those members from any particular section who are interested in the same line of work to informally appoint a Chairman at the Annual Meeting. In the absence of this step the members of the Committee might act in their respective sections for their co-workers who specialize on the same group of crops.

The initiative for organizing summer meetings would rest with the members of any section, but the Committee considers that immediate action would be profitable in many cases.

TREASURER'S REPORT

Receipts

Balance from 1914.		$509 06	
Dues for -			
10 members 1913 and 1914	$30 00		
281 members for 1915	843 00		
1 life member	50 00	923 00	
Exchange from 8 members		1 25	
Dr. Farlow's gift to Society		50 00	
Patron's fee from M L Delafield, Jr		100 00	
Interest December, 1914, to November, 1915, inclusive		13 59	$1,596 90

Expenditures

Printing, postage, etc	$66 50	
Printing abstracts	73 51	
Traveling expenses	162 47	
Members' subscriptions to PHYTOPATHOLOGY	584 00	
Clerical work	33 10	
Exchange on two Canadian checks	27	
Miscellaneous	21 41	941 26
Balance		$655 64

FINANCIAL STATEMENT OF BUSINESS MANAGER OF PHYTOPATHOLOGY[1]

Receipts

Balance from 1914	$120 71	
Williams & Wilkins subscriptions and sales	781 66	
Sales back numbers and reprints direct	71 26	
Subscriptions 292 members American Phytopathological Society.. . ..	584 00	
American Phytopathological Society appropriation	200 00	
Interest December, 1914, to November, 1915, inclusive	1 94	1,759 57

Expenditures

Balance due Williams & Wilkins from 1914 .		$127 64
Williams & Wilkins, mfg PHYTOPATHOLOGY, Vol. V:		
No. 1.	$426 22	
No. 2. .	177 81	
No. 3..	318 80	
No. 4	146 02	
No. 5... .	170 97	
No. 6 (bill incomplete) paid	200 00	1,439.82

[1] When the $150 00 guarantee from advertising is received and the other bills for 1915 paid there will be a balance of about $60 00

These accounts were referred to an Auditing Committee, consisting of W. J. Morse, E. C. Stakman, and P. J Anderson, by which they were examined and approved. The report of the Committee was adopted by the Society.

Brought forward		$1,759.57
Williams & Wilkins, miscellaneous	$53.00	
L. R. Jones editorial work, etc	15.25	
American Phytopathological Society for Eastham dues paid Williams & Wilkins	3.25	
Hartig plate	30.00	
Clerical work $31.70, stationery 60c	32.30	
Reddick, D., postage and expressage	5.00	
Williams & Wilkins, insurance	5.40	1,711.66
Balance		$47.91

RESOLUTIONS ADOPTED

Resolved, That the American Phytopathological Society heartily endorses the House of Representatives bill No. 528, entitled A Bill to discontinue the use of the Fahrenheit thermometer scale in Government publications and adopt instead the Centigrade scale of temperature measurements.

WHEREAS, This Society recognizes the great and increasing value of the Experiment Station Record as a scientific review journal; and

WHEREAS, It would add much to its value if it contained the original titles of all articles abstracted; be it therefore—

Resolved, That the American Phytopathological Society respectfully urges the importance of this matter upon the attention of the Honorable Secretary of Agriculture and the Editors of the Experiment Station Record in the hope that they may find it practicable so to handle future publications.

The Society lost two members, Dr. C. E. Bessey and Dr. W. Ralph Jones, by death during the year. The following statement and resolution were adopted unanimously by the Society and copies sent to the relatives of the Deceased:

Dr. Charles E. Bessey was a charter member of the Society and one of the oldest and best-known botanists in this country. He was also the beloved and respected teacher of many of the members of the Society. Dr. W. Ralph Jones was a scientific assistant in pathology in the Bureau of Plant Industry and a young man of unusual ability and promise as an investigator.

Resolved, That the Society hereby expresses its deep sense of loss in the death of these members, and believes that the greatest tribute to their memory is the record of the work which they have accomplished.

Upon invitation from the Second Pan American Scientific Congress President Whetzel appointed W. A. Orton Delegate and C. L. Shear Alternate Delegate to represent the Society. The Council submitted through its Delegates the following resolution to the Congress:

Resolved, That there be appointed by the Congress a permanent Committee on Pan American Plant Pathology, to be composed of specialists from all participating countries, to consider all matters relating to the occurrence and spread of plant diseases, the promotion of research and discovery of control measures, the development of closer and more intimate international scientific relations, cooperation in plant disease surveys, plant quarantine, and other problems of mutual interest; also to urge the establishment as a branch of the Pan American Union of a central Bureau for the promotion of the above-named objects.

The Society unanimously approved of this resolution and sent a telegram offering greetings to the Congress and urging favorable action on the resolution.

In view of the great value of definite knowledge and available record of the occurrence and distribution of the parasitic diseases of cultivated plants in the United States and the probability that such diseases will increase, be it

Resolved, That the American Phytopathological Society respectfully requests The Honorable Secretary of Agriculture to provide for the publication of the results of the plant-disease surveys of the several States from the data already available and in such form as to admit of the use of these results by all collaborators, investigators, and teachers of Phytopathology, and also to arrange for the reissue of such publication at such intervals as seem desirable; and further—

Resolved, That a copy of these resolutions be sent to The Secretary of Agriculture.

Resolved, That the Society expresses its deep appreciation and thanks to the Local Committee and the members of the Department of Botany of the University of Ohio for the excellent facilities provided and for the many courtesies extended during this meeting.

MISCELLANEOUS BUSINESS

Upon motion the Society voted to appropriate two hundred dollars or such part thereof as necessary towards the support of PHYTOPATHOLOGY for 1916.

Upon motion it was voted to approve of the action of the Council during the year in authorizing the payment of expenses of the Secretary to attend the Berkeley meeting; also the authorization of the Council permitting the Business Manager of PHYTOPATHOLOGY to expend such amount as necessary to provide clerical assistance, and such other ad interim acts as the Council had found it necessary to perform.

The question of continuing the present plan of publishing abstracts was thoroughly discussed at a smoker held by the Society Thursday evening, December 30. Various arguments, both pro and con, were presented. At the business session Friday morning, December 31 it was voted to continue the printing of abstracts for use at the meetings. The Secretary was instructed not to receive abstracts after December 1, and not to accept those containing over two hundred words, and members were requested to restrict them to one hundred words whenever possible. Members were also advised if they do not expect to attend the meeting to submit their abstracts in the form of notes for publication under this head in the JOURNAL.

In view of the scarcity of back numbers, it was decided to raise the price of back volumes of PHYTOPATHOLOGY to five dollars each beginning July 1, 1916, and of single numbers to eighty-five cents each. Since the selling of single numbers of back volumes frequently breaks up sets of the JOURNAL and causes much loss no odd back numbers will be sold after July 1 unless they occur in volumes already broken.

On account of the loss of numbers of the JOURNAL sent to delinquent members the Secretary was instructed to send out bills for dues in November hereafter and to withhold the JOURNAL from those whose dues have not been received by January 15.

Owing to the great risk of loss in forwarding copies of PHYTOPATHOLOGY to Europe under present conditions it is necessary that all such copies be sent at the subscribers' risk, and lost numbers can not be supplied free. If desired subscribers may have their copies held for them until such time as they may desire to have them for-

warded. It was also decided to allow sixty days hereafter for forwarding notice of missing numbers.

In view of the great assistance given by Miss Oberly in the preparation of the list of literature for the JOURNAL the Business Manager was authorized to supply the Library of the Department of Agriculture with a free copy of PHYTOPATHOLOGY, and also with a set of the Index Cards to Literature when published.

C. L. SHEAR,
Secretary-Treasurer

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

December, 1915 to January, 1916

Arthur, Joseph Charles, and **Fromme, Fred Denton.** New species of grass rusts. Torreya **15,** no. 12: 260–265. December, 1915.

* **Babcock, D. C.** Potato diseases and seed potatoes. Ohio Agr. Expt. Sta. Mo. Bul **1,** no. 1: 10 14, illus. January, 1916

Barrus, Mortier Franklin. An anthracnose-resistant red kidney bean. Phytopathology **5,** no 6: 303 311, 4 fig. December, 1915.

Colletotrichum lindemuthianum.

Bartholomew, Elbert T. A pathological and physiological study of the black heart of potato tubers. Centbl. Bakt. [etc.] II, **43,** No. 19/24: 609 639, 3 pl. (1 col.). June 4, 1915.

Literature cited, p. 637 638.

Bartram, H. E. Effect of natural low temperature on certain fungi and bacteria. Jour. Agr. Research **5,** no. 14 651 655. January 3, 1916.

Bioletti, Frederic T. Control of Oidium or vine mildew. California Cult. **46,** no. 2: 40 41, 58. January 13, 1916.

---- and **Flossfeder, F. C. H.** Oidium or powdery mildew of the vine. California Agr. Expt. Sta. Circ. 144, 12 p., 7 fig. 1915.

Boncquet, P. A., and **Hartung, W. J.** The comparative effect upon sugar beets of Eutettix tenella Baker from wild plants and from curly top beets. Phytopathology **5,** no. 6: 348 349, 1 fig. December, 1915.

Burrill, A. C. Insect control important in checking fire blight. Phytopathology **5,** no. 6: 342–347. December, 1915

Literature cited, p. 347.

Bacillus amylovorus.

Canada. Department of Agriculture. Division of Botany. Regulations under the destructive insect and pest act governing the importation, sale, shipment and exportation of the common or Irish potato (Solanum tuberosum L.). Canada Dept. Agr. Expt. Farms Div. Bot. Farmers' Circ. 6, 14 p. 1914.

Cardin, Patricio. Informe del departamento de patologia vegetal y entomologia. Cuba Estac. Expt. Agron. 3d Informe An. **1909/14**: 98–173, 5 pl. 1915.

Cook, Melville Thurston. The pathology of ornamental plants. Bot. Gaz. **61,** no. 1: 67 69. January, 1916.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C

Coons, George Herbert. Factors involved in the growth and the pycnidium formation of Plenodomus fuscomaculans. Jour. Agr. Research **5**, no. 16: 713-769. January 17, 1916.

Literature cited, p. 766-769.

Dodge, Bernard Ogilvie. The effect of the host on the morphology of certain species of Gymnosporangium. Bul. Torrey Bot. Club **42**, no. 9: 519-542, pl. 28-29. September, 1915.

Eastham, John William. Powdery scab of potatoes (Spongospora subterranea (Wallr.) Johns.) Canada Dept. Agr. Expt. Farms Div. Bot. Farmers' Circ. 5, 13 p., illus. 1914.

Edgerton, Claude Wilbur. A new method of selecting tomatoes for resistance to wilt disease. Science n. s. **42**, no. 1095: 914-915. December 24, 1915.

Fusarium lycopersici.

—— Seed bed sanitation. Louisiana Agr. Col. Ext. Div. Circ. 9, 16 p., illus. 1915.

Fawcett, Howard S. Citrus diseases of Florida and Cuba compared with those of California. California Agr. Expt. Sta. Bul. 262: 149-210, 24 fig. 1915.

Garman, Harrison. How to avoid potato scab and dry rot. Kentucky Agr. Expt. Sta. Newspaper Bul. 82, 1 p. 1914.

"(1) The selection of sound seed, (2) treatment with formalin or corrosive sublimate, and (3) rotation, are the means by which both of these pests may be avoided."

—— Twig blight and pear blight. Kentucky Agr. Expt. Sta. Circ 2, 8 p., 4 fig. 1915.

Bacillus amylovorus.

Gilbert, A. H., and **Myer, D. S.** Stem rot of clovers and alfalfa as a cause of "clover sickness." Kentucky Agr. Expt. Sta. Circ. 8: 45-60, illus. 1915.

Sclerotinia trifoliorum Erik.

Grossenbacher, John Gasser. Citrus pests and diseases. When and with what to spray for them. Florida Grower **13**, no. 2: 11-12. January 12, 1916.

— Some bark diseases of citrus trees in Florida. Florida Grower **13**, no. 2: 7-9, 18-19, 7 fig. January 8, 1916.

Güssow, Hans Theodor. Report of the division of botany. Canada Expt. Farms Rpts. **[1913]/14**, 2: 831-838. 1915

Harter, Leonard Lee. Sweet-potato scurf. Jour. Agr. Research **5**, no. 17: 787-791, pl. 57-58. January 24, 1916.

Monilochaetes infuscans.

Heald, Frederick De Forest, and **Studhalter, Richard Arthur.** Seasonal duration of ascospore expulsion of Endothia parasitica. Amer. Jour. Bot. **2**, no. 9: 429-448, 6 fig. November, 1915.

Literature cited, p. 447-448.

—— and **Woolman, H. M.** Bunt or stinking smut of wheat. Washington Agr. Expt. Sta. Bul. 126, 24 p., 5 fig. 1915.

Tilletia tritici or *Tilletia foetans.*

Hotson, John William. Fire blight on cherries. Phytopathology **5**, no. 6: 312-316, pl. 14. December, 1915.

Bacillus amylovorus.

Humphrey, Clarence John, and **Fleming, Ruth Mary Bates.** Toxicity of various wood preservatives. Jour. Indus. and Engin. Chem. **6**, no. 2: 128-131, February, 1914; **7**, no. 8: 652-658, illus., August, 1915.

Jehle, Robert Andrew. El tizon tardio y la pudricion de la papa. Cuba Estac. Expt. Agron. Circ. 48, 6 p., 6 fig. 1915.
Phytophthora infestans.

Johnston, John Robert. La enfermedad del platano en Cuba. Cuba Estac. Expt Agron. Circ. 47, 13 p., 7 pl. 1915.

Jones, Lewis Ralph, and **Bartholomew, Elbert T.** Apple rust and its control in Wisconsin. Wisconsin Agr. Expt. Sta. Bul. 257, 30 p., 14 fig. 1915.
Literature, p. 29 30.

— and **Gilman, J. C.** The control of cabbage yellows through disease resistance. Wisconsin Agr. Expt. Sta. Research Bul. 38, 70 p., 23 fig. 1915.
Literature cited, p. 69 70.
Fusarium conglutinans.

Kezer, Alvin. Treatment of seed grain to prevent smut. Colorado Agr. Expt Sta. Press Bul. 19 (ed. 2), 4 p. 1915.

Long, William Henry. A honeycomb heart-rot of oaks caused by Stereum subpileatum. Jour Agr. Research **5**, no. 10. 421 428, pl. 41. December 6, 1915.

Lutman, Benjamin Franklin. The combat with plant disease. 6th Ann. Rpt. Com. Agr. Vermont **1913/14**: 108-112 1914.

Lyman, George Richard, and **Rogers, John Terrell.** The native habitat of Spongospora subterranea. Science n. s **42**, no. 1096: 940 941 December 31, 1915.
Discovery of fungus on potatoes from Peru

Meinecke, Emilio Pepe Michael. Peridermium harknessii and Cronartium quercuum. Science n s. **43**, no 1098 73. January 14. 1916.

Melchers, Leo Edward. The grouping and terminology of plant diseases. Phytopathology **5**, no. 6: 297-302. December, 1915.

Meyer, Louis. To smudge or not to smudge. Country Life Amer. **29**: 37, illus November, 1915.

Morris, O. M. Winter injury of fruit trees more common in northwest. Better Fruit **10**, no. 6: 19 21. December, 1915.

Morse, Warner Jackson. Some diseases of the potato. 13th Ann. Rpt. Com. Agr. Maine **1914**: 346 361, 14 pl. 1915.

Nowell, William. New light on the witch-broom disease of cacao. Agr. news [Barbados] **14**. no. 354 382. November 20, 1915.
Marasmius perniciosus.

— A stem disease of sugar-cane in Barbados. Agr. News [Barbados] **15**, no. 357: 14. January 1, 1916.
Cephalosporium sacchari.

O'Gara, Patrick Joseph. A fungus of uncertain systematic position occurring on wheat and rye. Science n. s. **43**, no. 1099: 111-112. January 21, 1916.

— A Phoma disease of western wheat-grass. Science n. s. **43**, no. 1099: 110 111. January 21, 1916.

— A Podosporiella disease of germinating wheat. Phytopathology **5**, no. 6: 323 326, pl. 15 16. December, 1915.
Podosporiella verticillata sp. nov.

Orton, Clayton Roberts, and **Adams, J. F.** Collar-blight and related forms of fire blight. Pennsylvania Agr. Expt. Sta. Bul. 136, 23 p., 13 fig. 1915.
Bacillus amylovorus.

Petch, Thomas. Citrus mildew. Phytopathology **5**, no. 6: 350-352. December, 1915.

Reddick, Donald, and **Crosby, C. R.** Dusting and spraying experiments with apples. New York Cornell Agr. Expt. Sta. Bul. 369: 305 356, fig. 70-84. 1916.

Rees, H. L. Always hill select potato seed. West. Washington Agr. Expt. Sta. Mo. Bul. **3**, no. 5: 8–11, illus. August, 1915.

—— Experimental spraying for blackberry anthracnose. West. Washington Agr. Expt. Sta. Mo. Bul. **3**, no. 8: 2–10, illus. November, 1915.

—— Late blight of celery. West. Washington Agr. Expt. Sta. Mo. Bul. **2**, no. 11: 11–18, fig. 5–8. February, 1915.

Robbins, Wilfred W., and Reinking, Otto A. Fungous diseases of Colorado crop plants. Colorado Agr. Expt. Sta. Bul. 212, 54 p., 19 fig. 1915.

Rosenbaum, Joseph. Phytophthora disease of ginseng. New York Cornell Agr. Expt. Sta. Bul. 363: 61–106, fig. 2–18. 1915.

São Paulo. Secretaria da Agricultura, Commercio e Obras Publicas. Mildiow. Bol. Agr. [São Paulo] **16**, no. 10: 836–845, Outubro; no. 11: 921–936, 4 fig., Novembro. 1915.

Selby, Augustine Dawson, Houser, True, and **Humbert, J. G.** How to disinfect tobacco plant beds from root-rot fungus, (Thielavia). Ohio Agr. Expt. Sta. Circ. 156: 5–8, 1 fig. 1915.

Smith, Elizabeth Hight. Pythiacystis infection of deciduous nursery stock. Phytopathology **5**, no. 6: 317–322, 4 fig. December, 1915.

Smith, Erwin Frink, and Bryan, Mary Katherine. Angular leaf-spot of cucumbers. Jour. Agr. Research **5**, no. 11: 465–476, pl. 43–49. December 13, 1915.

Bacterium lachrymans, sp. nov.

Smith, Ralph Elliott, and Boncquet, P. A. Connection of a bacterial organism with curly leaf of the sugar beet. Phytopathology **5**, no. 6: 335–342, 1 fig., pl. 17. December, 1915.

?Bacillus dianthi.

Stevens, H. E. Citrus canker—III. Florida Agr. Expt. Sta. Bul. 128, 20 p., 6 fig. 1915.

Pseudomonas citri.

Stewart, Alban. An anatomical study of Gymnosporangium galls. Amer. Jour. Bot. **2**, no. 8: 402–417, 1 fig. October, 1915.

Summary of literature cited, p. 415–416.

Stewart, Vern Bonham. Mildew on black currants. Phytopathology **5**, no. 6: 349. December, 1915.

?Sphaerotheca mors-uvae.

—— Notes on the fire blight disease. Phytopathology **5**, no. 6: 327–334. December, 1915.

Bacillus amylovorus.

U. S. Department of Agriculture. Federal Horticultural Board. Report [**1914**]/**15**, 11 p. 1915.

—— Service and regulatory announcements. September: 59–79, October 30; October: 81–86, 1 fig., December 4; November: 87–90, December 23. 1915.

U. S. Department of Agriculture. Bureau of Plant Industry. Report of the chief [**1913**]/**14**, 28 p., 1914; [**1914**]/**15**, 16 p., 1915.

Pathological investigations, [**1913**]/**14**, p. 2–6.

Plant pathological investigations, [**1914**]/**15**, p. 3–5.

Waldron, Ralph A. Physiological studies on the chestnut blight disease. Pennsylvania Agr. Expt. Sta. Ann. Rpt. **1912/13**: 152–156, illus. 1914.

Bibliography, p. 155–156.

Endothia parasitica.

Weir, James Robert, and **Hubert, Ernest Everett.** A serious disease in forest nurseries caused by Peridermium filamentosum. Jour. Agr. Research **5**, no. 17: 781-785. January 24, 1916.

Wilson, James K. Calcium hypochlorite as a seed sterilizer. Amer. Jour. Bot **2**, no. 8: 420 427. October, 1915.

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Woods, Charles D. Plant pathology. Maine Agr. Expt. Sta. Spec. Rpt. **1913**: 43-59. [1914.]

—— - Powdery scab of potatoes. Maine Agr. Expt. Sta. Spec. Rpt. **1914**: 26-33. 1915.

[PHYTOPATHOLOGY, for February, 1916 (**1**: 1-126, Pls. I-IV), was issued February 9, 1916.

PHYTOPATHOLOGY

VOLUME VI NUMBER 3

JUNE, 1916

PERIDERMIUM HARKNESSII AND CRONARTIUM QUERCUUM[1]

E. P. Meinecke

With Two Figures in the Text

INTRODUCTION

Peridermium harknessii was first reported on the Pacific Coast on *Pinus radiata* by Moore; Farlow and Seymour's[2] Host Index adds *P. contorta*, *P. ponderosa* and *P. sabiniana* to the list. Hedgcock[3] further reports it on *P. jeffreyi*. The writer has found it very common on *Pinus attenuata*, and occasionally also on *P. coulteri*. Of all these hosts *P. radiata*, *sabiniana*, *attenuata* and *contorta* are undoubtedly most subject to attacks from the fungus. Numerous galls appear on the same tree. The writer has counted thirty-seven galls on a sapling of *Pinus radiata*, three feet high, selected at random from a group of similarly affected trees. Another specimen contained thirty-four galls on a witches'-broom fourteen inches high which had developed from a large old gall on the main stem. Another tree (diameter at base three inches, height eight feet) had 173 galls. A fourth tree (diameter at base six inches, height twelve feet) carried not less than 529 galls.

There can be little doubt but that each gall is the result of an individual infection. The tissues, even between neighboring galls, are perfectly normal, and rather commonly a tree develops only one gall, which may grow to large size. Unless the mycelium kills its substratum, as is often the case, it may grow and cause the gall to enlarge for many years, but it is always strictly confined to the gall itself and its immediate surroundings.

[1] A preliminary note appeared in Science, n.s. **43**: 73. 1916.

[2] Farlow, W. G. and Seymour, A. B A provisional host index of the fungi of the United States, Part III, pp. 160-162.

[3] Hedgcock, G. G. Notes on some western Uredinae which attack forest trees. Mycologia **4**: 143. 1912.

The mycelium is unable to spread from the initial point of infection and thus produce a gall at some distant point.

The typical *Peridermium harknessii* very much resembles *Peridermium cerebrum* Peck. Since Shear[4] has proved that *Peridermium cerebrum* has as its alternate stage *Cronartium Quercuum* (Berk.), the occurrence of a Cronartium on *Quercus agrifolia* in California[5] made it appear possible that the two Peridermia were identical. Hedgcock and Long[6] call the eastern form on oak *Cronartium cerebrum*. The identity of the Californian Cronartium on oak with the eastern form not being definitely proved by inoculation, the old name *Cronartium Quercuum* in Shear's sense is, for convenience's sake, used in this paper.

The writer has found *Cronartium Quercuum* in its telial form in the immediate vicinity of *Pinus radiata* only on *Quercus agrifolia* near Monterey, Palo Alto and Menlo Park, California. Near the latter two places collections were also made by Mr. J. T. McMurphy. *Pinus radiata* in its natural range occurs only in an extremely limited area on the coast, but is planted extensively. *Quercus agrifolia* is common along the coast from Mendocino south, but does not even penetrate into the great valleys of the Sacramento and San Joaquin Rivers, much less into the Sierra Nevada, where *Peridermium harknessii*, so-called, is very common on *Pinus sabiniana*, *P. ponderosa* and *P. jeffreyi*, and above all, on *P. contorta*. In the regions inhabited by these pines other oaks, particularly *Quercus californica* and *Castanopsis chrysophylla* are common, both of which Hedgcock has successfully inoculated with aeciospores of *Peridermium cerebrum*. It is, therefore, still possible, that *Quercus californica* and *Castanopsis chrysophylla* or perhaps some of the other associated oaks, may be the alternate hosts of the so-called *Peridermium harknessii* on some of the Sierra Nevada pines. Farlow and Seymour (p. 161) name *Pinus ponderosa* as a host for *Peridermium cerebrum* Pk. However, no Cronartium has been found, to the writer's knowledge, on *Quercus californica* or *Castanopsis chrysophylla* in California.

Cronartium Quercuum is by no means common on *Quercus agrifolia* in the vicinity of *Pinus radiata*. In fact, one may say without exaggeration, that there seems to be no direct relation between the distance of oak from infected pines and the frequency of the Cronartium, even where the oak is standing close to heavily infected pines. Never very abundant, it is found as common on oaks standing isolated or one hundred to two

[4] Shear, C. L. Peridermium cerebrum Peck and Cronartium Quercuum (Berk.) Journ. Myc. **12**: 89. 1906.

[5] Arthur, J. C. North American Flora, 7^2: 122.

[6] Hedgcock, G. G. and Long, W. H. Identity of Peridermium fusiforme with Peridermium cerebrum. Journ. Agr. Res. **2**: 247. 1914.

FIG. 1. Gall of Peridermium harknessii on Pinus radiata with aecium. Result of direct aecial infection. Note the sharp line of demarcation at the basal end and the incipient witches'-broom formation in connection with the gall.

hundred yards and more from the nearest pines as on those in closest proximity to Peridermium galls. In the midst of an unusually heavy infection of Peridermium it is not uncommon to find the oaks immediately

FIG. 2. Typical older gall of Peridermium harknessii on Pinus radiata from type locality. The aecia are confluent but not typically cerebroid.

adjoining infected pines quite free from Cronartium. In many cases where old, richly sporulating galls stand within a foot of the nearest oak branches, so close that in a heavy wind they must necessarily touch each other, the oak leaves were found to be without a sign of Cronartium.

The infection of the oak leaves is not heavier in the lee of pines with richly sporulating galls than in other sites, although here, close to the ocean, the prevailing winds are very constant. The very uneven distribution of the fungus on *Quercus agrifolia* may find its explanation in racial characteristics and susceptibilities of the oak. The telial form on *Quercus agrifolia* is even less frequent than the uredenial form. The writer has found the latter locally plentiful on *Quercus densiflora* and *Quercus chrysolepis* along the Coast to the Oregon line, always without the telial form. On the Klamath River in the northwestern part of California near the coast the writer collected a uredenial form on *Quercus chrysolepis*, which caused a distinct witches'-broom. Possibly this is a new form; the formation of witches'-brooms, it seems, has never been observed in other uredinial infections on oak. Another Cronartium received through the courtesy of Messrs. J. T. McMurphy and J. W. Sheldon was collected in the middle of May in the Coast Range near Palo Alto, California on *Quercus durata*. *Quercus durata* is an evergreen shrub. The collection comes from a region where *Peridermium harknessii* is common on *Pinus attenuata* and *P. radiata*. Whether any of these pines occurred in the immediate vicinity of the infected oaks is not known.

Hedgcock[7] was successful in infecting several California oaks (*Quercus lobata, Q. densiflora, Q. californica*) and also *Castanopsis chrysophylla* with aeciospores from *Peridermium cerebrum*. His inoculations of two pines, *Pinus ponderosa* and *P. murrayana* (*contorta*), which are common bearers of the so-called *Peridermium harknessii* in California, with teliospores, supposedly from *Quercus rubra*, produced typical galls of *Peridermium cerebrum*. On the other hand, his inoculations of oaks with material of *Peridermium harknessii* on *Pinus radiata* from California, failed.

In 1912 Hedgcock[8] again reports that "repeated and careful inoculation with aeciospores of this Peridermium (*P. harknessii*) on the leaves of young oaks of a number of species failed to infect them, while at the same time, inoculation with *Peridermium cerebrum* Peck on the same species of oak trees brought about an infection, resulting in the uredinia and telia of *Cronartium Quercuum* (Brond.) Arth."

The possibility that these failures were due to loss of viability of the spores in transit prompted the writer repeatedly to try inoculations with fresh material on *Quercus agrifolia* and *Q. californica*. All these attempts were without success.

[7] Notes on Peridermium cerebrum Peck and Peridermium harknessii Moore. Phytopath. **1**:131. 1911.

[8] Mycologia **4**: 143.

Strong as are the reasons for assuming that *Peridermium harknessii* is identical with *Peridermium cerebrum*, there are well-founded considerations which make it imperative that the connection should actually be proved by inoculation. One of these is the apparent independence of *Cronartium Quercuum* and *Peridermium harknessii*. Another is the difference in appearance. The aecia of *Peridermium harknessii*, at least on *Pinus radiata*, are not typically cerebroid (fig. 2); they usually appear as separate sori and the rather delicate peridium breaks open very soon after coming up through the bark. A comparison of figure 2 and Hedgcock and Long's photographs (their plate XI) show the difference very plainly. More important is the apparent rarity in our Peridermium of pycnia exuding "abundantly a yellowish, sweet fluid" as on *Peridermium cerebrum*,[9] which are also mentioned by Shear.[10] In spite of diligent search the writer has only once succeeded in finding pycnia of *Peridermium harknessii* on a young gall on *Pinus jeffreyi* in early spring (April). The pycnia contained very small pycnospores and did not break through the bark. In the literature the writer does not find any other reference to pycnia on *Peridermium harknessii*. To these distinctions may be added the fact that in infections with *Peridermium harknessii*, particularly on *Pinus radiata*, *P. contorta* and *P. attenuata*, witches'-brooms are extremely common and that the galls very often continue to fruit for many years, both of which phenomena are rare in *Peridermium cerebrum* according to Hedgcock.[11] It is well to remember also, that all the numerous and careful attempts at infection of *Quercus agrifolia* with aeciospores of *Peridermium harknessii* have failed.

The typically spindle-shaped form (*Peridermium fusiforme*) which has recently been proved by Arthur and Kern[12] and by Hedgcock and Long (l.c.) to be identical with *Peridermium cerebrum*, apparently does not exist on the Pacific Coast or at least is very rare. The typical gall of *Peridermium harknessii* is always very well defined; the transition from stem to gall is never gradual, but always very abrupt. When the infection takes place in 1- and 2-years-old twigs, the swelling generally embraces the whole stem; in the next year these galls often take the shape of a pear, with the thick part downwards, and later become spherical. On a little older stems the swelling may be one-sided and later develop into a hemisphere. But whatever form the gall takes, it is always very clearly set off against the unthickened stem; this is particularly noticeable

[9] Mycologia **4**: 132.

[10] Jour. Myc. **12**: 91.

[11] Mycologia **4**: 143.

[12] Arthur, J. C. and Kern, F. D. North American species of Peridermium on pine. Mycologia **6**: 135. 1914

on the basal end of the gall, whilst the swelling at the apical end of very young galls is sometimes more gradual.

Whether these distinctions are sufficiently important to separate the two forms can only be decided by inoculations. Possibly most of them may be explained by the specific influence of the host. The actual proof for the identity of the two forms is still lacking, although Arthur and Kern[13] now list *Peridermium harknessii* under *P. cerebrum*.

For all the pines growing in association with oaks, it is to be assumed that the connecting Cronartium form may still be discovered. One species of pine that does not enter into this system is *Pinus contorta*, a tree which in the Sierra Nevada inhabits higher elevations and is particularly common around and on mountain meadows. Although frequently found associated with oaks or Castanopsis, it often occurs in localities sixty to eighty miles and more from the nearest representative of either genus. The infection of *Pinus contorta* with *Peridermium harknessii* is no less common in such areas, in fact, in some localities it reaches an extraordinarily high degree. Macroscopically the fungus is identical with *Peridermium harknessii* on *Pinus radiata*. It is true, that there are data to be found in the literature regarding great distances that certain spores are able to travel without losing their faculty of infection. Klebahn[14] cites a case in which spruce plants were infected by sporidia of *Chrysomyxa Rhododendri* from Rhododendron plants over a distance of 6 kilometers (v. Tubeuf) and quotes Thaxter as follows: "although it has been shown that infection from cedars may take place at a distance of eight miles (*Gymnosporangium nidus-avis*)." In both these cases, conclusive proofs for which it would undoubtedly be difficult to bring, the small and light sporidia are said to have traveled a long distance; in our case the fungus would have to be carried, by means of the large and heavy aeciospores, from pine to oak or Castanopsis for sixty to eighty miles over mountains and flat country, more or less covered by a thick screen of forest trees, and back again the same distance by means of sporidia. In the case of *Pinus murrayana* in the Northwest this distance must be figured by hundreds of miles.

The question arises as to the means by which the fungus spreads. Either this fungus on *Pinus contorta* connects with an unknown alternate host or it is identical with the *Peridermium harknessii* of *Pinus radiata*. In this case it must be more or less independent of the supposed alternate stage on oaks or Castanopsis and its heteroecism is not obligate.

The absence of oaks and Castanopsis in many *Pinus contorta* stands, the relative rarity of *Cronartium Quercuum* on *Quercus agrifolia* even in

[13] Mycologia 6: 133.

[14] Klebahn. Die wirtswechselnden Rostpilze. pp. 32–33.

the immediate vicinity of heavily infected *Pinus radiata* and its apparent absence on oaks and Castanopsis of the Sierra Nevada suggests the possibility that infection of what we call *Peridermium harknessii* on California pines may take place directly from pine to pine by means of aeciospores. This, of course, does not exclude the possibility of infection by sporidia, where Cronartium on oaks is present.

The idea in itself is not a new one. Eriksson,[15] in discussing the probable mode of dissemination of *Peridermium Pini*, for which no alternate host was known, came to the conclusion, without adducing any proof however, that infection must take place directly from tree to tree. Klebahn (pp. 40 and 380) on the other side considers the formation of aecia of heteroecious fungi from aeciospores or spermatia as a priori improbable. Mentioning Eriksson's failure to report a successful outcome of his direct inoculation experiments he even goes so far as to say "Es kann also hiernach auch als ziemlich sicher angenommen werden, dass eine Infektion der Kiefer mittels der Aecidiosporen nicht moglich ist.' Hedgcock, according to recent personal information, has tried direct inoculation with negative results.

EXPERIMENTATION

In the following, the results of the writer's experiments are given. The aecial material used was collected on the morning of May 22, 1913 from richly sporulating galls of typical *Peridermium harknessii* on *Pinus radiata* at Sausalito, Marin County, California, where the fungus is very common, but where in spite of the most careful and continued search no Cronartium could be found on the native *Quercus agrifolia*. Other oaks or Castanopsis do not occur in the vicinity. The material was kept dry and taken at once to San Francisco, California (a distance of a few miles only). The plants used for the inoculation experiments consisted of a series of four young trees of *Pinus radiata* (3-years-old) in pots, from a reliable nursery. They were about two to two and one-half feet high, in perfect health, thrifty and without a sign of Peridermium. We will designate them as I, II, III and IV. They were kept in the laboratory, in the center of San Francisco, where contamination from the outside is out of the question and where there existed no possibility of infection through sporidia from Cronartium on oak.

On May 22 and May 23, 1913, No. I was inoculated in seven places of different ages with aeciospores suspended in water, by wounding the sprayed bark with a sterilized needle and gently rubbing the infection

[15] Eriksson, J. Einige Beobachtungen über den stammbewohnenden Kiefernblasenrost, seine Natur und Erscheinungsweise. Centralbl. Bact. II Abt. 2: 385. 1896.

material into the wounds. Two of the wounds were left open, not bandaged. The others were wrapped in cotton and paper or protected by paper bags. The bandage was left on for a number of days. The wrapping made it necessary to cut off the bundles of needles in the neighborhood of the wounds. No. II was treated on May 23, 1913 in a number of places without wounding. The places chosen for inoculation were sprayed before and after the application of the spores. Here also the needles were cut. In other places dry spore material was dusted on after cutting the impeding needles and spraying. A sporulating gall was tied to a twig. All inoculations were protected by paper bags. All inoculated places were marked with colored twine.

III and IV were not inoculated. III was allowed to stand in a room together with I and II. IV was kept in a separate room.

A prolonged absence made regular inspections impossible. The plants, however, were sprayed regularly.

In December of 1913 several distinct oblong swellings, suggestive of *Peridermium harknessii* galls, were discovered on tree No. I on places inoculated in May. No. II also seemed to show a swelling in one place. This plant, however, soon began to decline and finally died. Immediately above the swellings on the younger parts of the living plant adventive buds began to sprout in the characteristic manner of witches'-broom formation so commonly observed above the galls of *Peridermium harknessii*. The other two plants of *Pinus radiata* remained in perfect health as did all other parts of the inoculated plant. Even No. III, which had been standing close to the infected plants for more than seven months showed no sign of infection.

During the winter of 1913–1914 the swellings, which had now become so typical that in nature one would without hesitation classify them as young galls of *Peridermium harknessii*, remained more or less stationary. No signs of pycnia or of aecia were apparent. The risk of losing the plants in the unfavorable conditions of a city laboratory made it advisable to transfer the trees to the open. On March 12, 1914 the remaining plants, Nos. I, III and IV were planted close together in the experimental garden of the Campus of the University of California, Berkeley, California. All through the year of 1914 the swellings were more or less stationary; the witches'-brooms became, if anything, a little more distinct. No signs of pycnia or aecia appeared. An inspection on March 3, 1915 brought the final result. The swellings on No. I had increased somewhat in size; the witches'-broom formation was very plain. Aecia had broken out, in each case in the very point of inoculation, indicated by a slight depression.

The photograph (figure 1) shows plainly the gall, with the aecium, and the beginning witches'-broom formation above.

The inspection of the infected trees on March 25, 1915 gave the following results:

Of the seven inoculations on tree No. I five had taken, four of which had produced well-defined aecia; two of these, on one-year twigs, produced slender barrel-shaped swellings, encircling the entire twig (one with an aecial row, about 7.5 mm. long, in the axis of the swelling; the other without an aecium, resin drops present in several places). Of the remaining three infections, one is represented by the photograph (figure 1); the swelling is of slender barrel shape. The aecium measures 1½ by 3 mm.; the swelling itself measures 3 cm. in length by 1.2 cm. in diameter as against 0.6 cm. of the stem immediately below. Another infection caused a gall to form around about one-half of the circumference of the stem; it bears a large aecium in the center. The third infection on the lower part of the stem (at least 3 years old) resulting in a gall about three-fourths around the circumference, has a small aecium in the center. The exact ages of the stem and twigs at the various places of infection could not be determined because the plant was kept for further observations.

As to the two unsuccessful inoculations, it will be remembered that in two cases the spore material had not been protected by cotton and paper and had probably dried up.

The control plants III and IV were in perfect health without a sign of *Peridermium harknessii*. All parts of plant I not inoculated remained sound. At the present time (December, 1915) the galls have grown considerably; the check plants and all not inoculated parts of tree I are perfectly sound.

The period of incubation as figured from the time of inoculation to the first manifestation of the effect of infection, in this case, of the swelling, must be about four to five months. The first appearance of aecia in the experiments took place about twenty months after inoculation. In nature, the first swelling appears in the fall of the year of infection. During the next year the young gall remains stationary or grows but little. In the spring of the third year, the aecia develop and sporulation begins.

In the experiments the one-, two- and three-years-old stems and twigs proved susceptible to infection; none were made on twigs younger than one year, because at the time of experimentation the buds had not yet sprouted sufficiently. In nature, infection of stems older than two years must be rare, at least no infection on older stems could be found in spite of careful examination of the great number of galls. Infection of twigs during their first year of growth, on the other hand, is frequent. Investigations of this kind must, of course, be made in spring, because the result of spring infection begins to show towards fall of the same year.

Examination of the galls produced in the experiments shows that the aecia and the aeciospores are typical for *Peridermium harknessii.*

Arthur[16] records under *Cronartium Quercus* (Brondeau) Schroet. 17 to 23 by 25 to 32μ for aeciospores on non-Californian pines. Arthur and Kern[17] give 15 to 21 by 23 to 31μ for *Peridermium harknessii* and 17 to 23 by 25 to 32μ for *Peridermium cerebrum.* Later they[18] gave 15 to 24 by 23 to 33μ for *Peridermium cerebrum,* in which they now include *Peridermium harknessii.* The measurements of the aeciospores of *Peridermium harknessii* resulting from direct aecial infection in our experiments are as follows:

(148) 11 to 26μ by 19 to 41μ (standard 17 to 22 by 24 to 30μ).[19]

Fresh material of *Peridermium harknessii* collected on *Pinus radiata* at the type locality near Monterey, California, measures:

(50) 11 to 24μ by 22 to 37μ (17 to 20μ by 26 to 30μ).

For comparison with these values the following measurements of aeciospores of *Peridermium harknessii* on various hosts including the two formulas given above may be of interest:

Pinus contorta (Rocky Mountains).

(50) 15-24 x 19 43 (17 19 x 22–26)μ.
(50) 15-24 x 20 37 (19-20 x 22–26)μ.
(50) 17-26 x 19 28 (19–22 x 20-26)μ.

Pinus contorta (Sierra Nevada).

(50) 13-22 x 19 33 (17–19 x 22–24)μ.
(50) 15-26 x 20 37 (17–20 x 22–26)μ.
(50) 13-22 x 17-30 (15-19 x 22-26)μ.
(50) 11–24 x 19 35 (17-20 x 22-26)μ.
(50) 15-26 x 19 31 (19–22 x 22-26)μ.
(100) 13 30 x 19 33 (17–22 x 22–28)μ.

Pinus jeffreyi.

(40) 13-26 x 17 33 (17-20 x 20–26)μ.

Pinus ponderosa.

(40) 11-22 x 20 35 (17-22 x 26–30)μ.
(50) 15 24 x 16 37 (17–20 x 24 30)μ.

[16] North Am. Fl. 7^2:122.

[17] Arthur, J. C. and Kern, F. D. North American species of Peridermium. Bul. Torr. Bot. Club **33**: 421 and 423.

[18] Mycologia **6**: 134.

[19] (148) gives the number of spores measured, then follow the extreme values and finally in parenthesis the standard values. See Meinecke, E. P., Spore measurements. Science, n.s., **42**: 430. 1915.

Pinus radiata.

(50) 11–24 x 22–37 (17–20 x 26–30)μ.

Pinus radiata (aecial infection).

(148) 11–26 x 19–41 (17–22 x 24–30)μ.

Pinus attenuata.

(28) 19–30 x 26–41 (20–22 x 26–30)μ.

Pinus sabiniana.

(50) 15–24 x 20–37 (17–20 x 26–30)μ.

Pinus virginiana (eastern form).

(50) 15–24 x 22–37 (19–22 x 26–31)μ.

The values for the extreme measurements in this list vary so much that a composite formula would read: 11 to 30 by 16 to 43μ. It is plain that the extremes cannot be used for comparison.

If we consider the standard values only, it appears that the widths vary very little from the values 17 to 22 μ. The lengths, however, permit us to distinguish two well-defined groups, one wth the values 22 to 26 μ and another with the values 26 to 30 μ. The slight variations from these values lie well within the unavoidable margin of error in measuring and in rounding off the figures obtained. The first group includes all the specimens on *Pinus contorta* (*murrayana* from the Rocky Mountains), *P. contorta* (Sierra Nevada), and *P. jeffreyi*, that is, high elevation forms; the second group, the material from *Pinus ponderosa*, *P. sabiniana*, and *P. radiata*, that is, forms from the middle and lower slopes of the Sierra Nevada and from the coast little above sea level. To the latter group must be added *Peridermium cerebrum* from *Pinus virginiana*. Further inoculation experiments will have to decide the question whether or not these groups actually correspond to two different fungi. Obviously too great an importance must not be accorded to spore measurements unless they are well supported by other structural and biological characters. Morphologically all the aeciospores examined resemble each other very closely. On the other hand, the remarkable regularity of standard values as shown, for instance, in nine specimens from *Pinus contorta* on the basis of five hundred measurements, suggests the usefulness of such spore measurements for purposes of identification. That our material from *Pinus contorta* has nothing to do with *Peridermium filamentosum* which is very common in the same localities, is shown by a comparison with the formula for aeciospores of the latter fungus (numerical basis 100):

(100) 17–39 x 22–78 (22–26 x 30–33)μ.

The fact that the standard values for *Peridermium cerebrum* on *Pinus virginiana* are practically the same as those for *P. harknessii* on *Pinus*

radiata, *P. ponderosa*, *P. attenuata*, and *P. sabiniana* furnishes new evidence for the assumption that the two forms on the hosts named are identical, without, of course, proving it.

FACULTATIVE HETEROECISM OF PERIDERMIUM HARKNESSII

The experiments prove that *Peridermium harknessii* is able to infect at least *Pinus radiata* directly by aeciospores, that is, with omission of the telial stage, if there is any. In other words, although it is highly probable that the fungus is heteroecious, this heteroecism must be facultative. The same is very probably true for the so-called *Peridermium harknessii* on *Pinus attenuata* and *P. contorta* and perhaps for that on the rest of the Sierra Nevada species of pines.

Haack[20] published—one year after the writer began his experiments, and, of course, independently--positively results of direct aecial inoculation of *Peridermium Pini* on *Pinus sylvestris*. His first experiments were inconclusive; he, therefore, later inoculated pines already heavily infected, reasoning that these individuals would be more susceptible to the disease. This latter procedure together with the fact that he operated entirely in the open, already infected forest, makes his otherwise valuable experiments inconclusive. The results of my inoculations of *Pinus radiata* with *Peridermium harknessii* lend a strong support to the outcome of Haack's experiments.

Like others before him, Haack suspected that wounding of the bark is a prerequisite for successful inoculation and assumes that insects are largely responsible for such injuries. Hedgcock[21] states that "in nature, young Peridermium galls are often found associated with wounds made by an insect." On older parts of the tree the fungus "may gain entrance through wounds made by birds (sapsuckers), but this hypothesis remains to be proven."

All the writer's observations go to show that insects play an important, if not a decisive, rôle at least in direct aecial infection of the fungus from pine to pine. The common presence of old wounds in connection with *Peridermium harknessii* galls and the type of distribution of the galls on the individual tree as well as on a group of trees speak against promiscuous infection from a shower of wind-borne spores. When the infection is not general, the galls are usually found only up to a certain relative height, depending on the height and crown development of the

[20] Haack. Der Kienzopf (Peridermium pini (Willd.) Kleb.) Seine Übertragung von Kiefer zu Kiefer ohne Zwischenwirt. Zeitschr. Forst- und Jagdw. **46**: 3–46. 1914.

[21] Phytopath. **1**: 132.

tree and of the group of trees of which it is a part. In one of the examples given in the introduction to this paper, only five galls out of a total of 173 were over five feet from the ground. In another case only about twenty out of 529 were found above six feet from the ground. Often they are found only on one side of the tree or the group, unevenly distributed. Since we must assume that at the time of spore dissemination all the young twigs and branches are equally susceptible to infection, a shower of spores would find equal conditions for germination and penetration of the bark, at least in a majority of twigs or branches, and the infections would be more evenly distributed over the crown. The fact that in our experiments inoculation with wounding was successful in five out of seven cases and gave only one very doubtful result in the unwounded tree which subsequently died, speaks for the intervention of insects in nature.

All other causes of wounds through which infection could take place are absent in the case of *Pinus radiata* and *P. attenuata*. The winters of their habitat are very mild; the summers too cool for sun-scorch. Lightning and hail are practically unknown.

The common occurrence of spittle-bugs (*Aphrophora* sp.) on young stems and twigs of *Pinus radiata* may have some significance. During spring, that is, at the very time when the galls of *Peridermium harknessii* are in full sporulation, the writer found them profusely at Monterey, California, throughout the very heavily infected stands. The larvae of this cercopid wound the young stem by puncturing it. Provided the spittle contains no ingredients harmful to the aeciospores caught in it, the latter would find ideal conditions for germination by being kept moist for a considerable time. When the spittle dries up they would automatically be drawn onto the fresh wound made by the insect. It is to be noted that the spittle-bugs are nearly always located on young stems and twigs which are still protected by needles. The writer's inoculations show that not only the youngest stems, but also at least three-years-old ones may be artificially infected. In nature this is rare; so are spittle-bugs on three-years-old stems.

Hedgcock and Long[22] find that the swellings of *Peridermium fusiforme* "on the three-needle pines often originate near the extremity of a branch, and, as the side branches develop, the fungus invades them, producing an enlargement of the base of each branch." *Pinus radiata* is a three-needle pine and similar enlargements of the base of each branch of a whorl are not uncommon. Spittle-bugs very often are located on the whorl at the base of the branches.

[22] Jour. Agr. Res. **2**: 248.

FACULTATIVE HETEROECISM OF CRONARTIUM QUERCUUM

Recent inspections of oaks of the infected area on the Monterey peninsula disclosed an apparent parallelism between the facultative nature of the heteroecism of *Peridermium harknessii* and that of *Cronartium Quercuum*. The relative scarcity of the latter in the immediate vicinity of the former has already been pointed out. At the time of the first observation (first half of April) no Cronartium in its telial form had developed, but uredinial sori were fairly common on young leaves and more frequent on old green ones. The leaves of *Quercus agrifolia* remain living and green on the tree throughout winter and often until late in spring. On last year's green leaves fresh urediniospores came forth more or less abundantly from the old Cronartium spots, generally in a circle immediately around the dark-brown, dead, sunken-in places occupied last year by the Cronartium. The mycelium of the fungus, therefore, evidently overwinters in the leaf and produces urediniospores in the following spring, which are able in their turn to infect the young sprouting leaves. Hedgcock[23] has successfully inoculated *Quercus lobata*, *Q. californica* and *Castanopsis chrysophylla* with urediniospores from *Quercus rubra*. It is, of course, not impossible that some of the uredinial sori on the young leaves were the results of infection from aeciospores from *Peridermium harknessii* on *Pinus radiata*. The numerical relation of these sori to the old ones, however, speaks for an infection through urediniospores rather than through aeciospores from *Peridermium harknessii*, at least early in the season. Later infection from Peridermium may become more plentiful. Inspection of the same stands in the beginning of May did not disclose an increase in sori. The sporulation (uredo) on young leaves had all but stopped. No telial stage was found. The old green leaves were still on the trees, but sporulation on these had stopped altogether.

The Cronartium on another evergreen oak, *Quercus durata*, mentioned above, seems to behave in a similar manner. Here the uredinial sori were not very numerous on last year's leaves and were distinctly rare on this year's foliage, which was about one-third developed. The sori are smaller than on *Quercus agrifolia*, but here again the old sori produced urediniospores in quantities. The urediniospores are rather large. Occasionally very small telial columns were found; it was impossible to decide whether these were the product of last year or recently formed.

This uredinial infection explains the occurrence of *Cronartim Quercuum* in apparent independence of a heavy infection of *Peridermium harknessii*.

The heteroecism of the Californian *Cronartium Quercuum* seems to be facultative as is that of *Peridermium harknessii* on *Pinus radiata*.

[23] Phytopath. 1: 131.

SUMMARY

Although not definitely proved, it is highly probable that *Peridermium harknessii* is identical with *P. cerebrum*. In California *Peridermium harknessii* and *Cronartium Quercuum* are to a high degree independent of each other.

The so-called *Peridermium harknessii* can be transmitted directly from pine to pine by infection with aeciospores, at least on *Pinus radiata;* in nature this probably takes place through the agency of insects. The heteroecism of *Peridermium harknessii* on *Pinus radiata* is, therefore, facultative. By analogy it is highly probable that the same facultative heteroecism occurs in *Pinus contorta* and perhaps also in the other hosts of the so-called *Peridermium harknessii.*

Cronartium Quercuum overwinters on *Quercus agrifolia;* new urediniospores form in spring around the old, dead sori on old living leaves and infect the young leaves. The heteroecism of the Cronartium also is facultative.

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IV.

FUNGOUS FLORA OF TEXAS SOILS

Frederick C. Werkenthin

With One Figure in the Text

HISTORICAL INTRODUCTION

Although it was generally recognized that the soil contained many forms of fungi, prior to 1886 very little work seems to have been done on the fungous flora of the soil.

Adametz[1] seems to have been the first investigator who attempted seriously to isolate soil forms and to give them names and descriptions. His work not only includes names and descriptions of bacteria, yeasts, and molds found in the soil, but it also includes a discussion of the chemical processes brought about by these soil organisms.

Nikitinsky[2] isolated thirty forms of bacteria and four species of fungi: *Penicillium glaucum*, *Aspergillus niger*, *Mucor mucedo*, and *Trichothecium* sp.

The most extensive work as to the number of species isolated from the soil is that of Oudemans and Koning.[3] The isolation was carried out by Koning, while the classification of the species was made by Oudemans. They reported forty-five species from a humous soil of the Forest of Spanderswoud, near Bussum, in Holland. Of these, thirty-two were described and named as new species.

Reference may here be made to van Iterson's[4] work on soil fungi, though his results are of doubtful value because of his method of isolation, as will be seen from the following quotation: "As inoculation material one can use soil or humus, but the best results one gets, if one exposes the petri dishes to the air for twelve hours."

[1] Adametz, Leopold. Untersuchungen uber die Niederen Pilze der Ackerkrume. Inaug. Diss. Leipzig: 1–78. 1886.

[2] Nikitinsky, J. Ueber die Zersetzung der Huminsubstanzen durch physikalisch-chemische Agentien und durch Mikroorganismen. Jahr. Wiss. Bot. **37**: 365–420. 4 fig. 1902.

[3] Oudemans, C. A. J. A. und Koning, C. J. Prodrome d'une flore mycologique obtenue par la culture sur gelatine préparée de la terre humeuse du Spanderswoud près de Bussum. Extr. des Archives Neerlandaises des Science, ex. et. nat., 267–298, pl. 1–41. 1902.

[4] Van Iterson, C. J. Die Zersetzung von Cellulose durch aerobe Mikroorganismen. Centbl. Bakt. u. Par., abt. 2, **11**: 689–698, pl. 1. 1904.

Much credit is due to Butler[5] for his excellent treatise on the genus Pythium. Although he refers only incidentally to soil forms, yet his work must constitute a valuable part of the literature that we are discussing because of the species he has unquestionably shown to be soil organisms. He isolated six species of the genus Pythium.

Hagem[6] examined different soils, such as arable, meadow, garden, and forest soil for Mucorales, and isolated sixteen species of this order.

In 1908, Lendner[7] published the results of his study of the distribution, culture and classification of the Mucorales. Nine species were isolated.

In 1910, Hagem[8] published two papers on the Mucorales. Of interest to us in this connection is a chapter in his second paper in which a general discussion is given of the distribution of these fungi in various soils. In his conclusion he says: "The composition of the flora of Mucorales differs with the character of the soil. The Mucorales of cultivated soil differ very much from those of forest soil, and consist of new species entirely. The optimum temperature for Mucorales seems to lie between 20°-25°C." The first paper deals with descriptions of species isolated.

Namyslowski[9] isolated *Zygorrhynchus Vuilleminii* Namy., *Mucor microsporus* Namy., and *Rhizopus arrhizus* Fischer from the soil.

In 1911, Beckwith[10] isolated from wheat soils of North Dakota, eleven species from nine genera of imperfect fungi.

Jensen[11] in a discussion of obligate saprophytes has attempted to make a monograph of all those species of fungi that have been thus far isolated from or found in the soil. His investigations were restricted to a study of the fungi of arable soil. The first three samples, *A*, *B*, *C*, were taken in July, August, and September from an oat field near the Agricultural College at Ithaca, New York. Sample *D* was taken in October from a

[5] Butler, E. J. An account of the genus Pythium and some Chytridiaceae Mem Dept. Agr. India, Bot Ser 5, 1: 1 160, pl. 10. 1907.

[6] Hagem, Oscar. Untersuchugen uber Norwegische Mucorineen I. Videnskabs-Selskabets Skrifter I. Math.-Naturv. Klasse, no. 7. 1–50. 1908.

[7] Lendner, Alfred Les Mucorinees de la Suisse Berne. 1–180. 1908.

[8] Hagem, Oscar. Neue Untersuchungen ueber Norwegische Mucorineen. Ann Mycol. 8: 265 279 1910

—— Untersuchungen ueber Norwegische Mucorineen II. Videnskabs-Selskabets Skriften I. Math.-Naturv Klasse. no. 4: 1 152. 1910.

—— Einige Beobachtungen ueber die Verbreitung der Actinomycetes in der Natur. Videnskabs-Selskabets Skriften I. Math.-Naturv. Klasse no. 7: 202. 1910.

[9] Namyslowski, B. Zygorrhynchus Vuilleminii une novelle Mucorineen Isolee du sol et cultivee. Ann. Myc. 8: 152 155. 1910.

[10] Beckwith, T. D. Root and culm infections of wheat by soil fungi in North Dakota. Phytopath. 1: 170–176. 1911.

[11] Jensen, C. N. Fungous flora of the soil. Cornell University, Agr. Exp. Sta. Bul. 315: 415–501. 1912.

barrel of soil shipped from East Hampton, Long Island, New York. The soil was a sandy loam and, in 1910, had grown a crop of potatoes. The harvest had been small on account of disease caused by *Oospora scabies* Thaxter, *Corticium vagum* B & C., var., *Solani* Burt, and *Fusarium oxysporum* Schlecht. None of these three fungi, however, were isolated from the Long Island soil. Samples *E, F, G, H* and *I* were taken from the plant-breeding experimental garden east of New York State College of Agriculture at Ithaca, New York. Samples *J, K, L, M, N*, and *O* were taken from a potato field near Atlanta, New York.

In his conclusion he says: "More should be known of those fungi generally recognized as facultative parasites. Are not some of the species carried over from year to year on or in the seed, or do they live as saprophytes in the soil during the winter? Too often it is said without the proper evidence that a fungus is a soil organism. It seems to the writer that if a more detailed and far-reaching study were made of this phase of the question, it would be far more renumerative in many instances than the study of the control alone, after fungi have made a sick soil."

In the same year, 1912, Miss Elizabeth Dale[12] published a paper on soil fungi. Two samples of a light and sandy soil were taken from adjacent plots on the Royal Agricultural Society's Farm at Woburn, England. In all, over thirty-five species were obtained, some from both samples, others from only one. Twenty-two were found in plot *A*, and only thirteen in plot *B*.

Bolly's[13] experiments and observations in regard to the relation of root and soil diseases to wheat cropping have led him to believe that "sick soils" are due to fungi. In his discussion he says. "These experiments show clearly that certain species or strains of Fusarium, Helminthosporium, Alternaria, Macrosporium, Colletotrichum, and Cephalothecium are directly capable of destroying or attacking growing plants of wheat, oats, barley, bromegrass, and quack-grass." Studies were made in pots and plots upon the fungus and bacterial flora of wheat-sick soil as influenced by special methods of fertilizing. Certain methods of fertilizing and purifying such soil really influence the growth of the fungi in the soil, yet he found no soil condition in which wheat can thrive, in which the root fungi may not also persist in sufficient quantities to injure the crop. "The disease producing fungi are seldom absent from any single piece of land."

[12] Dale, Elizabeth. On the fungi of the soil. I. Sandy soil. Ann. Mycol. **10**: 452–477, pl. 9–14. 1912.

[13] Bolley, H. L. Wheat: Soil troubles and seed deteriorations. North Dakota Agr. Exp. Sta. Bul. 107: 1–91. 1913.

Goddard[14] while investigating the question of the assimilation of nitrogen by soil fungi, isolated nineteen species from a garden plot of rather rich clay loam at Ann Arbor, Michigan. In his summary of results he says: "Many species of fungi live habitually in the soil, carrying out their life history there, either in whole or in part. A considerable number of these have been found, so far, only in the soil. These fungi are, at least to quite an extent, uniform in different soils, and, unlike the bacteria, appear to be rather uniformly distributed at different depths, at least as low as 14 cm."

Miss Dale's[15] earlier work was continued by an examination of the fungous flora of three other samples of soil. Twenty-nine species were isolated from "chalky soil," twenty species from "Peat," and eighteen species were taken from "Black Earth."

PRESENT INVESTIGATION

Selection of plots. The present investigation was restricted to a study of fungi from three different kinds of soil. Samples *B*, *E*, *G*, *I*, and *M* were taken in October, November, January, and February from a cotton field on the Fiskville Road, three miles north of Austin, Texas. The crop had been gathered before the first sample was taken, and the field was left unplowed until February. At that time the dead cotton plants were plowed under. The soil of this field, according to the Bureau of Soils of the United States Department of Agriculture, is "Austin Clay."[16] The soil is derived from the weathering of a soft limestone formation, known as Austin chalk. The soil to an average depth of ten inches is a dark brown to black loam, containing a large percentage of silt and clay. Small particles of partially disintegrated limestone are usually present on the surface and in the soil.

Samples *A*, *D*, and *L* were taken in October, November, and February from flower beds of the University greenhouse. The soil had been richly manured, and geranium and other greenhouse plants had been planted the year before.

Samples *C*, *F*, *H*, and *K* were taken in October, December, January and February from the University Campus. An unfrequented place, which had lain undisturbed for at least twenty years was selected. Scanty

[14] Goddard, H. N. Can fungi living in agricultural soil assimilate free nitrogen. Bot. Gaz. **56**: 249-305, figs 1-18. 1913.

[15] Dale, Elizabeth. On the fungi of the soil. II. Ann. Mycol. **12**: 33-62, pl. 1-5. 1914.

[16] Magnum, A. W. and Belden, H. L. Soil survey of the Austin area, Texas. U. S. Dept. Agr., Bureau of Soils; Field operations of the Bureau of Soils, Sixth Rept., 421-446. 1904.

grass had grown on the plot for several years, but no external organic matter had been added to the plot except that which had been blown upon it by winds or washed upon it by rains. The soil on this plot is also "Austin Clay." The soil is shallow, the limestone being only six to seven inches below the surface. It is comprised to a great extent of partly disintegrated limestone.

Culture media. The following media were given a thorough trial for the isolation of soil fungi: Soil extract agar, agar-agar, glucose agar, potato decoction agar, gelatin agar, raisin extract agar, bean decoction agar, carrot decoction agar, beer wort agar, and prune decoction agar.

The "soil extract" agar, as used by Jensen, was without question far superior to all media tried for isolation. The formula for this medium is as follows:

Distilled water	800 cc.
Soil extract	200 cc.
Dextrose	10 0 grams
Dipotassium phosphate (K_2HPO_4)	0 5 gram
Magnesium sulphate ($MgSO_4$)	0 2 gram
Agar-agar	15 0 grams

The "gelatin" agar, used with such success by Goddard, proved to be a failure for the present investigation on account of the tendency toward liquefaction. Miss Dale's raisin extract agar also did not work out as successfully as expected, and was abandoned after several trials.

For the pure culture tubes, all of the above mentioned media as well as bean pods, carrot plugs, and Raulin's culture fluid, were used.—Naturally no one medium was uniformly satisfactory in causing the fungi to fruit. Mucor species seemed to grow best on bean pods; while species of Aspergillus grew more luxuriantly on glucose agar, beer wort agar, and carrot plugs. Miss Dale's method of keeping the stock cultures on sterile carrot plugs seemed to be very satisfactory in the present investigation.

Method of taking soil samples. All samples were obtained by the same method. The instrument for taking the samples was built with slight modifications after the sampler used by Goddard. The sampler consists of a brass tube, three-fourths of an inch inside diameter and seven inches long. An iron rod, operating as a piston, was fitted inside the tube. At the top end of the tube, a collar was attached through which operated a small thumb screw for holding the rod in any position desired. The opposite end was sharpened for entering the soil. The iron rod was graduated so as to indicate the size of each soil sample in inches. At the top, the iron rod was rounded to form a convenient knob for holding. A view of the sampler is given in figure 1.

The samples were taken as follows: The sampler, having been set for the depth of the sample desired, was sterilized by means of dipping it several times in a solution of 95 per cent alcohol. After removing the very topmost layer of soil with a sterile scalpel, the sampler was inserted into the soil by a rotary motion. Samples were taken from one to seven inches below the surface to study the distribution of fungi according to depth. With a sterile scalpel a part of the sample, about one or two grams, was transferred to a sterile, cotton-stoppered tube containing 10 cubic centimeters of bouillon. The tubes containing the inoculated bouillon were taken to the laboratory.

FIG. 1. Soil sampler used in the investigations.

Method of isolation. Each sample was thoroughly shaken, and as soon as the coarser soil particles had settled, five loopsful were transferred by means of a sterile platinum needle, to the first of a series of two tubes, each containing ten cubic centimeters of soil extract agar which had been melted previously and cooled to 43°C. From tube 1, five loopsful were transferred to the second. Plates were then poured in the usual way. During the winter months the plates were incubated at 27°C. for forty-eight hours. After two days incubation, bacteria showed up in great abundance. But, a day or two later the fungi had outgrown the bacteria, and isolations could be made easily. Pure cultures were obtained in this way, but sometimes dilution plates were poured to separate a mixture of soil fungi. In a few instances soil samples, transferred to a sterile, cotton-stoppered test tube, were taken to the laboratory, and fungi were isolated by the planted plate method, used by other investigators. Small masses of soil that could be taken on the point of a sterile scalpel were taken from the tube and planted in petri dishes containing soil agar. By this method some of the rapidly growing fungi will crowd out the slower-growing organisms.

List of fungi isolated. Sample A. October 6, 1914. *Rhizopus nigricans* Ehrenberg, *Mucor racemosus* Fresenius, *Aspergillus ochraceus* Wilhelm, *Aspergillus niger* van Tiegh., *Aspergillus* sp. (no. 5), *Ramularia magnusiana* (Sacc.) Lindau.

Sample B. October 13, 1914. *Aspergillus niger* van Tiegh., *Fusarium Solani* (Martii) App. & Wr., *Cladosporium herbarum* Pers., *Aspergillus ochraceus* Wilhelm.

Sample C. October 29, 1914. *Aspergillus ochraceus* Wilhelm, *Aspergillus* sp. (no. 5), *Aspergillus* sp., resembling the albus-candidus-okazakii

group, *Fusarium Solani* (Martii) App. & Wr., *Fusarium oxysporum* Schlecht, *Mucor racemosus* Fresenius.

Sample D. November 4, 1914. *Penicillium* sp., variety of *P. luteum* Zukal, *Aspergillus niger* van Tiegh., *Aspergillus fumigatus* Fres. *Aspergillus ochraceus* Wilhelm.

Sample E. November 17, 1914. *Aspergillus niger* van Tiegh., *Aspergillus ochraceus* Wilhelm, *Cladosporium herbarum* Pers., *Ramularia magnusiana* (Sacc.) Lindau, *Fusarium Solani* (Mart.) App. & Wr.

Sample F. December 15, 1914. *Aspergillus venetus* Massal., *Aspergillus* sp. (no. 5); *Fusarium Solani* (Mart.) App. & Wr., *Fusarium oxysporum* Schlecht.

Sample G. January 5, 1915. *Aspergillus ochraceus* Wilhelm, *Aspergillus niger* van Tiegh., *Rhizopus nigricans* Ehrenberg.

Sample H. January 21, 1915. *Aspergillus* sp., resembling the albus-candidus-okazakii group, *Aspergillus fumigatus* Fres., *Fusarium radicicola* Wollenweber, *Fusarium Solani* (Martii.) App. & Wr., *Basisporium* sp.

Sample I. January 28, 1915. *Rhizopus nigricans* Ehrenberg, *Aspergillus niger* van Tiegh., *Aspergillus ochraceus* Wilhelm, *Aspergillus venatus* Massal, *Fusarium oxysporum* Schlecht, *Fusarium radicicola* Wollenweber.

Samples *I 4* and *I 5* were taken at depths of one and two inches below the bottom of a four inch furrow, the total depth being therefore five and six inches. From these samples no fungi were isolated.

Sample K. February 9, 1915. *Aspergillus* sp. resembling the albus-candidus-okazakii group; *Mucor racemosus* Fresenius, *Aspergillus niger* van Tiegh., *Cladosporium herbarum* Pers.; *Ramularia magnusiana* (Sacc.) Lindau.

Sample L. February 9, 1915. *Aspergillus niger* van Tiegh., *Aspergillus ochraceus* Wilhelm, *Mucor racemosus* Fresenius, *Rhizopus nigricans* Ehrenberg, *Ramularia magnusiana* (Sacc.) Lindau, *Aspergillus fumigatus* Fres., *Penicillium* sp.

Sample M. February 10, 1915. *Aspergillus niger* van Tiegh., *Aspergillus* sp. resembling the albus-candidus-okazakii group, *Aspergillus fumigatus* Fres., *Aspergillus venatus* Massal, *Basisporium* sp.

Samples M *4* and M *5* were taken at depths of one and two inches below the bottom of a four inch furrow, the total depth being therefore five and six inches. No sign of fungus growth could be found in the plates poured from these samples.

These fungi, after isolation, were studied with reference to the following points: (1) distribution as to depth; (2) distribution as to kind of soil and frequency of appearance; and (3) structural characters and identification. These will be considered in the order given.

Distribution as to depth. The studies of distribution according to

depth were made on all three plots previously indicated. Samples were taken at six different depths: one inch, two inches, three inches, four inches, five inches, and six inches.

The number of colonies appearing in each sample was counted and the average percentage for each depth determined.

The average for twelve samples is as follows: One inch, 25 per cent; two inches, 30 per cent; three inches, 30 per cent; four inches, 15 per cent; five inches and six inches, none. The comparative results indicate that the fungi of the soil were distributed rather uniformly at depths from one to three inches. No fungi appeared at a depth of five or six inches. These results seem to coincide with those of Goddard.

Distribution as to kind of soil. As previously stated, the three plots were different as to the kind of soil, tillage, and fertilization. A marked difference was expected in the flora of the different plots, especially in plot I as compared with plot II. The soil of plot I was cultivated soil, while the soil of plot II had remained untouched for at least twenty years. Almost all fungi isolated from plot I were also isolated from plot II. Out of about 150 isolations, representing fifteen different species but one species was found exclusively on plot I, while two species were found exclusively on plot II. Five species found in plot I and plot II were not found in plot III. One species (Penicillium) was only found in plot III. A summary of the results is given in table 1.

TABLE 1

Summary of isolations of fungi from different plots of soil

PLOT I	PLOT II	PLOT III
Fungi isolated from cotton field	Fungi isolated from University Campus	Fungi isolated from University greenhouse
Aspergillus niger	Aspergillus niger	Aspergillus niger
A. ochraceus	A. ochraceus	A. ochraceus
A. venetus	A. venetus	....
....	A sp. (No. 5)	A. sp. (No. 5)
A. sp., (albus-candidus-okazakii group)	A. sp. (albus-candidus-okazakii group)	....
A. fumigatus	A. fumigatus	A. fumigatus
Fusarium Solani	Fusarium Solani	....
F. oxysporum	F. oxysporum	....
F. radicicola	F. radicicola	....
Ramularia magnusiana	Ramularia magnusiana	Ramularia magnusiana
Cladosporium herbarum	Cladosporium herbarum	Cladosporium herbarum
Rhizopus nigricans	....	Rhizopus nigricans
Basisporium sp.	Basisporium sp.	....
....	Mucor racemosus	Mucor racemosus.
....	....	Penicillium sp.

In order to show the frequency of the occurrence of the genera and species in the soils investigated a table has been worked out (table 2).

TABLE 2

List of fungi arranged according to the frequency of appearance in soil samples

NAME OF FUNGUS	TOTAL NUMBER OF APPEARANCES
Aspergillus niger	30
Aspergillus ochraceus	28
Aspergillus sp. (No. 5)	18
Aspergillus venetus	15
Aspergillus sp. (albus-candidus-okazakii group)	12
Aspergillus fumigatus	12
Cladosporium herbarum	8
Rhizopus nigricans	6
Mucor racemosus	5
Fusarium Solani	5
Ramularia magnusiana	5
Fusarium radicicola	4
Basisporium sp.	4
Fusarium oxysporum	3
Penicillium sp.	2

LIST OF FUNGI OBTAINED FROM SAMPLES

The species are arranged according to the classification adopted by Engler and Prantl.[17]

Mucor racemosus Fresenius. Isolated from sandy and loamy arable soils, Germany, by Adametz; from sandy, loamy soil from potato field, Long Island, N. Y., by Jensen; from sandy soil from a plot on the Royal Agricultural Society's Farm at Woburn, England; from chalky soil from the Gog Magog Hills near Cambridge, England; and also from "black earth" from a farm near Ely, England, by Miss Dale; from Texas soils five times by the author.

Rhizopus nigricans Ehrenberg. Isolated from soil, Norway, by Hagem; from soils, Germany, by Adametz; from plant breeding plots near Cornell University during the winter 1910–1911, by Jensen; and also isolated six times by the author from Texas soils during 1914–1915.

Aspergillus niger van Tiegh. Isolated from sandy soil from a plot near the Royal Agricultural Society's Farm at Woburn, England, by Miss Dale; also isolated thirty times from Texas soils by the author.

[17] Engler and Prantl. Natürlichen Pflanzenfamilien. 1897.

Aspergillus ochraceus Wilhelm. Isolated twenty-eight times from Texas soils by the author, who is indebted to Dr. Charles Thom for the determination of this fungus.

Aspergillus sp. (no. 5). Dr. Thom states in a letter that he has a description and figures of this species, but is not as yet satisfied to offer a name. Colonies light brown at first, later chocolate brown. Sterile hyphae 2 microns thick. Conidiophores 3 to 5 microns in diameter, of light brown color. Conidial heads brown, 14.5 to 15 microns in diameter. Sterigmata branched, on all sides, primary 4.5 to 5 microns long, 3 microns in diameter, secondary 4 microns long, 2 microns in diameter. Conidia spherical with rough surface, 2.2 to 2.5 microns in diameter, of light green color.

Very common in Texas soils. Isolated eighteen times by the author.

Aspergillus venetus Mossal. Isolated from Texas soils fifteen times by the author.

Aspergillus sp. resembling the albus-candidus-akazakii group. Colonies white. Conidiophore 2 to 4 microns in diameter, colorless. Condial heads white, small, 12 to 14 microns in diameter. Sterigmata not branched, 5 to 7 microns long, 2.5 microns in diameter. Conidia very numerous, 2 to 3 microns in diameter, spherical, almost colorless.

This Aspergillus produces asci on Beerwort agar. The asci are 2.6 by 5 microns and contain from six to eight ascospores, 1 by 1.5 microns.

Found in twelve samples taken from Texas soils by the author, who is indebted to Dr. Charles Thom for the identification of this fungus.

Aspergillus fumigatus Fres. This Aspergillus is apparently the same as *Aspergillus* sp. No. 7, isolated by Miss Dale from sandy soil. The colonies are at first white, but in a few days the center turns yellowish green and the edges take a dark shading. After ten to fourteen days the center changes its color again and turns deep yellow to yellowish green, surrounded by a zone of yellowish cream color. Conidial heads almost colorless, 15 microns in diameter. Sterigmata not branched, 4 to 6 microns long, 2 to 3 microns in diameter. Conidia numerous, 2 microns in diameter, spherical, yellowish in color.

Isolated twelve times from Texas soils by the author, who is indebted to Dr. Charles Thom for the identification of this fungus.

Penicillium sp., var. of *Penicillium luteum* Zukal. Conidiophores a thin and incomplete layer, scantily produced mostly as lateral branches of aerial hyphae, 20 to 100 microns (mostly 30 to 45 microns) by 3 microns. Conidial heads usually small, up to 80 microns in length, commonly with a single lateral branch and but two verticils of long acuminate basidia 13 to 16 by 3 to 4 microns; rather firm walled, greenish. Isolated only twice from Texas soils by the author.

Dr. Thom says that these species differ in details of reaction and general appearance of colony, but harmonize in certain essential structures and reactions to such a degree that he hardly dares to separate the various races found.

Cladosporium herbarum (Pers.) Link. Isolated by Miss Dale, from sandy soil, chalk, and uncultivated mountain peat. Common in Texas. Isolated eight times by the author.

Basisporium sp. The young colonies form a very characteristic radiating silky mass of branching hyphae, shining and white. The mycelium is colorless, septate, and branched, 1 to 1.5 microns in diameter, bearing at intervals along its hyphae the roundish brown spores with a light center (oil spots). The spores are 3.5 by 4.8 microns.

Isolated four times from Texas soils by the author. Still pending identification from Dr. Thom.

Fusarium radicicola Wollenweber. Found on partly decaying tubers and roots of plants, such as *Solanum tuberosum* in Europe and America (collected by Wollenweber[18]) and *Ipomoea batatas* in the United States of America (collected by Harter and Field). Also found as inhabitant of the soil in Texas (isolated four times by the author).

The author is indebted to Dr. Carpenter for this determination.

Fusarium Solani (Mart.) App. & Wr. Saprophyte common on potatoes and various other hosts both in Europe and America. Isolated from sandy soil from a plot on the Royal Agricultural Society's Farm at Woburn, England, by Miss Dale, and five times from Texas by the author, who is indebted to Dr. Carpenter for this determination.

Fusarium oxysporum Schlecht. Isolated from Texas soils three times by the author, who is indebted to Dr. Carpenter for the determination of this fungus.

Ramularia magnusiana (Sacc.) Lindau. Found in Germany in humus, Dahlem, March, 1911; isolated from Texas soils five times by the author, who is indebted to Dr. Carpenter for the determination of this organism.

DISCUSSION

It will be seen from the foregoing that cultivation of soils does not seem to change the flora of soil fungi. The samples taken from the cot-

[18] Wollenweber, H. W. Studies on the Fusarium problem. Phytopath. **3**: 24–50, 5 pls. 1913.

—— Ramularia, Mycosphaerella, Nectria, Calonectria. Eine Morphologisch-Pathologische Studie zur Abgrenzung von Pilzgruppen mit Cylindrischen und Sichelformigen Konidienformen. Phytopath. **3**: 197–242, pl. 20–22. 1913.

—— Identification of species of Fusarium occurring on the sweet potato, Ipomoea batatas. Jour. Agr. Research **2**: 251–285. 1914.

ton field yielded, with two exceptions only, the same kind of fungi as did the samples taken from the University campus. Hagem's statement, that "the Mucorales of cultivated soil differ very much from those of forest soil and consist entirely of new species," does not hold true for the present investigation as shown in table 1.

Of special interest in the study of soil fungi is the fact that the virgin soil contained fungi which are known to be parasitic to cultivated plants, e.g., *Fusarium Solani* (Mart.) Sacc., *Fusarium oxysporum* Schlecht, and *Fusarium radicicola* Wollenweber. It also should be noted that these fungi were isolated several times from the same plot during a period of over five months, which fact should show clearly that these fungi are true inhabitants of the soil. These data give a satisfactory answer for these species to Jensen's question: "Are not some of the species carried over from year to year on or in the seed, or do they live as saprophytes in the soil during the winter?" The present investigation proves clearly that these fungi live as saprophytes in the soil at least through the winter months, and it seems reasonable to assume that they must live saprophytically throughout the year.

In regard to the depth it must be said that the fungous flora was almost the same for depths ranging from one to four inches. This fact coincides with the results of Adametz, who found the same species indifferently in the shallower or deeper levels. Some study was also made by Goddard in regard to the depths at which particular fungi were found. He says: "Any particular species seemed about as abundant at one depth as at another, down as deep as samples were taken."

The foregoing results would indicate that there is a rather constant and characteristic fungous flora in the soil. The dominant type in Texas seems to be species of Aspergillus, while species of Mucor and Penicillium occur only occasionally. Species of Aspergillus occurred one hundred and fifteen times in the plates taken from Texas soils, while Species of Mucor were isolated only five times, and Penicillium but twice. According to Hagem, the optimum temperature for the Mucorales lies between 20 and 25°C. The present investigation seems to show that species of Aspergillus studied have a decidedly higher optimum temperature than species either of the Mucorales or of Penicillium. At incubator temperature (27°C.) all of the species of Aspergillus isolated showed a much more rapid and vigorous growth than those of the Mucorales or Penicillium. The optimum temperature of these Aspergilli probably reaches 30°C.

The total number of the most abundant species isolated by Jensen, Goddard, and the author are given in the following table:

NAME OF INVESTIGATOR	TOTAL NUMBER OF ISOLATIONS FROM A SPECIES OF			
	Aspergillus	Penicillium	Mucor	Fusarium
Jensen	5	14	5	3
Goddard	—*	—*	14	13
Author	30	1	5	5

* The total number is not given

From this table it appears that in northern climates the dominant soil fungi seem to be species of Penicillium, while in the South, species of Aspergillus are the leading type.

SUMMARY OF RESULTS

1. Up to the depth of four inches, soil fungi are fairly uniformly distributed. In deeper regions, below four inches, no viable fungous spores seem to be present.
2. There does not seem to be any variation of fungi in regard to cultivated or virgin soil.
3. The climate seems to have great influence on the flora of soil fungi. Species of Aspergillus are the dominant soil fungi of the South; Penicillii, so frequently found in northern states, are rare in Texas soils; the Mucorales are not as abundant in southern soils as they are in colder climates.
4. Pathogenic fungi, especially species of Fusarium, live in the soil as saprophytes throughout the winter.

This work has been directed by Dr. Fred McAllister, whose kindly assistance, helpful suggestions, and criticisms have greatly aided and encouraged the work. The writer also takes pleasure in expressing his sincere thanks to Dr. Charles Thom, Dr. C. W. Carpenter, and Dr. A. F. Blakeslee for their kind assistance given in the identification of fungi.

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A WILT DISEASE OF THE COLUMBINE

J. J. TAUBENHAUS[1]

WITH TWO FIGURES IN THE TEXT

In the summer of 1913, the writer's attention was attracted to a serious disease of the garden columbine, *Delphinium* sp. The disease was so severe as to practically destroy the entire planting. An examination of the diseased plants showed them plainly to be affected by the fungus *Sclerotinia libertiana* Fckl. A search through the literature failed to show any record of a Sclerotinial disease that affects the columbine. This host is of economic importance to the florists and gardeners, in-so-far as it is grown and sold as an ornamental plant.

The disease is characterized by a general wilting of the leaflets and tender shoots, accompanied by a slow drying of the affected branches. Usually the disease progresses slowly, affecting one by one the main branches of the plant (fig. 1). The roots of the plants are not attacked by the fungus and frequently during periods of prolonged dry weather badly diseased plants may recover. On the other hand, with continued rainfall the roots of diseased plants may die from the attacks. A close examination of newly infected plants shows the presence of a webwork of white fungus strands on the diseased stems. These hyphae penetrate deeply into the interior, and the freshly invaded tissues appear water-soaked. In splitting lengthwise an infected stem, the hollow interior is seen to be filled with white fungus hyphae and numerous sclerotia in various stages of formation. The sclerotia are about three to four millimeters in diameter and in stems killed by the fungus the numerous hard, black sclerotia practically fill the center of the dead stem (fig. 2, a and b). In appearance, these sclerotia resembled those of *Sclerotinia libertiana* Fckl.

Four young, healthy columbine plants were planted in pots and kept in the greenhouse for four weeks, in order to make sure of the absence of any disease. Previous to the time of inoculation, the four plants were covered with bell glasses for about twelve hours, in order to create a saturated atmosphere. Two of the plants were then inoculated with a pure culture of the fungus, which had been isolated previously from a diseased columbine plant growing in the field. The fungus was grown in a tube of potato agar, and the entire contents of the tube was placed at the foot of

[1] Formerly of the Delaware Experiment Station where this work was performed.

the inoculated plants The other two plants were not inoculated and served as checks. The bell glasses were removed from the four plants twenty hours after inoculation. After about two days the inoculated plants showed a wilted appearance and were affected at the base of the stem. The symptoms of the disease were characteristic of the affected plants found in the field The fungus was easily reisolated and the Sclero-

FIG. 1. Columbine plant partly killed by the wilt fungus.

tinial growth was again the dominant feature This proved that the Sclerotinia-like fungus is the cause of the columbine wilt Attempts were made later to inoculate the two healthy check plants with a pure culture of the above Sclerotinial fungus, but the plants were not covered with bell glasses and infection failed to take place. This indicates that moisture is an important factor in enabling the fungus to attack the host plant.

In order to determine the identity of the fungus, numerous sclerotia were collected from dead vines and from pure cultures. The sclerotia were buried to a slight depth in pots of sand and exposed to the weather throughout the winter. Early the following spring, the sclerotia from both dead vines and from pure cultures were found to germinate and to

FIG. 2. Sclerotia and apothecia of Sclerotinia libertiana. *A*, dead stem split longitudinally to show sclerotia; *B*, sclerotia; *C*, germinated sclerotia of Sclerotinia libertiana, taken from dead columbine vines.

produce apothecia (fig. 2, c). In measurement of asci and ascospores, as well as in other characteristics, the fungus was found to be identical with *Sclerotinia libertiana* Fckl. Ascospores from the germinated sclerotia when placed on nutrient agar produced a growth typical of *S. libertiana*, so that there could no longer be any doubt as to the specific position of the fungus.

Sclerotinia libertiana on the columbine may winter over as sclerotia in manure which is often used as a mulch. In fact, the disease was found to originate in the columbine planting of the Delaware Agricultural Experiment Station garden where manure was used as a mulch.

TEXAS AGRICULTURAL EXPERIMENT STATION
COLLEGE STATION, TEXAS

SOME NEW STRAWBERRY FUNGI[1]

F. L. STEVENS AND ALVAH PETERSON

SPHÆRONÆMELLA FRAGARIÆ AS THE CAUSE OF A STRAWBERRY ROT

Berries affected with the Sphæronæmella rot disease shrink, lose their normal color and soon become covered with the gelatinous, glistening pycnidia of the fungus. This disease was first noticed in Louisiana in 1914. Later it was found on berries in the markets at Urbana where it was so common that of the boxes brought to the laboratory a large proportion of the berries developed the disease. It was again observed both in Louisiana and in the Urbana markets in 1915. It is not primarily of great significance since its development is not very rapid. In the case of berries which receive a ready sale it probably is of little consequence. The disease is, however, of significance since through its lesions more destructive fungi e.g. Rhizopus, can enter.

Berries affected with this disease do not show a definitely limited spot either superficially or in section. The affected area becomes tan colored, the berry shrivels and within a few days the whole berry is affected. The surface of the berry becomes closely studded with the tan- to dark-colored pycnidia. These, due to their peculiar gelatinous texture, give to the affected berries a characteristic feeling so that the disease may usually be recognized by this character alone. Section of a diseased berry shows the interior discolored (tan), moist but not excessively wet or soft.

The mycelium completely occupies the tissue below the pycnidia and produces a spongy texture. The mycelial threads are hyaline and vary in diameter from coarse, 7 μ, to fine, 1.5 μ. They are frequently septate with many of the old cells empty. Strands often taper rapidly from the coarse to the fine form. Branches are often at right angles. The filaments are usually nearly full of spherical highly refractive droplets.

The pycnidia originate as mycelial knots below the epidermis and develop to considerable extent subepidermally. They finally become erumpent and are at first tan-colored, but often, though not always, assume a blackish external tint as they age. The sporiferous part is spherical about 500 to 700 μ in diameter, normally simple but sometimes lobed and chambered. The rostrum is about 300 μ long above the pycnid-

[1] A brief statement concerning these fungi was made in Science **41**: 912. 1915.

ium and about 150 μ thick. When wet the rostrum in optical section exhibits a central dark region surrounded by a sheath which is translucent being composed of hyphæ that are more loosely woven and of more gelatinous texture than those in the central region. The pycnidium especially the rostrum is loosely covered with long tangled gelatinous hairs.

The spore chamber is filled with conidia borne on basal and lateral conidiophores. The conidiophores are hyaline and simple, about 2 μ thick and 15 to 17 μ long, rarely 24 μ long.

The spores are cylindrical with rounded ends, measure 0.5 to 6.5 by 1 to 1.5 μ, are continuous and hyaline.

The fungus was isolated by the following means: (1) By dilution plating of the spores. (2) By direct planting of pycnidial spores. (3) By direct planting of mycelium from the interior of a diseased berry.

The fungus grows readily on various media producing a very luxuriant, characteristic mycelium which however under many conditions fails to produce pycnidia. Thus mycelial transfers to poured plates always result in rapid growth of very dense colonies, but usually without pycnidia until the colony is very old (2 to 3 weeks). Then at the edge of the colony a few pycnidia may or may not develop. Sometimes, though rarely, such colonies later become pycnidial in their central regions. When, however, spores were thickly sown in plates so that from one hundred to two hundred colonies developed per plate, each colony bore a pycnidium at its center and often others as well.

On corn meal agar the colony was hyaline and slow-growing. Pycnidia formed first at the margin, later toward the center. The colonies were very dense, of entire but wavy margin and the surface showed a glistening satin-like appearance and a wavy structure, difficult to describe, due to large numbers of filamentous crystals of unknown composition.

On artificial media, the pycnidia often grow in clusters, several arising from the same basal prominence. Also the beaks are frequently very hairy.

Numerous inoculations were made using both the mycelium and the spores suspended in sterile water and applied with a platinum loop, either with or without injury to the cuticle of the berry. Results of inoculations were somewhat unsatisfactory since the berry could not be sterilized and since both this fungus and the species of Patellina described later, were so commonly present upon the berries used. Conclusions could therefore be drawn only from the differences between the inoculation sets and the control sets. There were, however, so many positive results of spots at the exact point of inoculation that there can be no doubt of the causal relation of the fungus to the rot.

The pycnidium of such distinctly gelatinous or waxy texture clearly places the fungus in the order Sphæropsidales, in the family Nectrioidaceæ, and in the sub-family Zythieæ. The spore characters place it in the Hyalosporæ. The family Nectrioidaceæ is singularly free from aggressive parasites. Indeed, with the exception of the genus Zythia it finds no place in economic literature.

The beaked pycnidium together with the other characters presented agree fully with Sphæronæmella in which genus the fungus belongs.

This genus contains according to Saccardo's Sylloge Fungorum some nineteen species which grow upon wood, bark, fungi, dung, ferns and herbs.

The species as described in the Sylloge Fungorum have been tabulated (table 1). They are arranged in the order of the minimum spore length and such other data are included as were available and comparable. It is seen, that allowing for reasonable variation in spore size and in the measuring of spores, only numbers six to nine and fourteen to nineteen can be considered. Of these, numbers seven, eight, sixteen and seventeen are excluded by the length of the rostrum. Number six is eliminated by comparison with an authentic specimen of the North American Fungi Collection No. 2566, because of the different shape of the spores. Numbers nine and fifteen are eliminated for the same reason. Number eighteen is eliminated by its appendiculate spores and numbers fourteen and nineteen are so meagerly described as to be unidentifiable.

The species in hand seems to be distinct from any heretofore described. We therefore describe it as:

Sphæronæmella Fragariæ n. sp.

Pycnidia erumpent, globose, 670 μ in diameter, gelatinous or waxy, tan-colored, varying to almost black in outer cells, base partially immersed, height including beak 1000 to 1100 μ, beak when dry 150 μ thick, when wet with a swollen translucent envelope, often densely hairy, especially the beak. Spores cylindrical, obtuse, straight, 5 to 6.5 by 1.5 μ. Condiophores simple, tapering, 15 to 17 to 24 by 2 μ.

Habitat. On fruit of cultivated Fragaria, Louisiana.

PATELLINA FRAGARIÆ

The disease caused by *Patellina Fragariæ* is first visible as small sunken discolored spots on the green or ripe strawberry. The areas are soon thickly set with the saucer-shaped sporodochia characteristic of the causal fungus. It was first noted on specimens collected in Louisiana in 1914; later in the same year it was observed at Urbana, Illinois, on market

berries from various sources. It was repeatedly collected from the same sources in the spring of 1915. In fact almost any box of berries, on standing a few days presented the disease, and in many cases a large percentage of the berries in a box showed the spots. That it is not merely a secondary organism appearing upon old berries is shown by the fact that it has been collected in the field upon berries still upon the vines, both upon ripe and upon green berries.

The spot upon green berries is tan-colored, somewhat sunken and en-

TABLE 1

A *tabulation of the species of Sphaeronaemella*

NUMBER	NAME	SACCARDO: Volume	SACCARDO: Number	PERITHECIA: Diameter	PERITHECIA: Length of rostrum	CONIDIA: Shape	CONIDIA: Length	CONIDIA: Breadth	HOST
				mm	*mm*		μ	μ	
1	microsperma	18	4810	1 9	3 5	spherical	0 8 1		Betula
2	mirabilis	10	6550	2 5 3	2 3	elliptical ovate	2 5–4	1 1 5	bark
3	cornuta	11	3570		3 4	ovoid	3	1	Cornus
4	mougeotii	3	3304			oblong allantoid	3	1	Hedera bark
5	filicina	10	6551		1	oval	3	2	Hymenophylli
6	Rosae	10	6548	0 2		elliptical	4 5 5 5	2 5 3	Rosa
7	Wentii	16	3785		9		7	4	Viciae
8	fimicola	10	6552	1 5 2 5	7 8 2	elliptical	7 7 5	2 2 5	dung
9	Helvellae	3	3312	1 2 1 5	3 5 5	elliptical	7 13	4 6	Helvella
10	rufa	3	3308			globose	9	2 5	Pinus Magnolia Clethra
11	diaphana	3	3306			elliptical	12	4	Larix
12	carnea	10	6549		2	oblong	15	4	Acer
13	macrospora	18	4811		1	elliptical ovate	21 22	8 10	bark
14	acicularis	3	3305						Quercus Pinus
15	flavo-viridis	3	3307			ovate	minute	minute	dead wood
16	cincta	3	3209		long				Pinus
17	aurantiaca	3	3310			ovoid	small	small	trunks
18	oxyspora	3	3311			elliptical appendiculate			Polyporus and Agarics
19	cucurbitula	16	3786	minute					Gomphidii
20				6 7	5	cylindrical	5 6 5	1 5	Fragaria

larges but slowly. Upon ripe berries the character of the spot is the same but its development is much more rapid. The central region of a spot which has attained a diameter of about seven to eight millimeters bears sporodochia. Two or three millimeters of the border of the spot are free from sporodochia. Cross, median sections through a spot show the affection to be deep, usually deeper than the diameter of the spot. The core of the affected host in that part is consumed and replaced by fungous my-

celium and thus presents a spongy dry texture. This core is separated from the unaffected host tissue by an intermediate zone two or three millimeters in thickness which contains no mycelium but the host, cells of which are separated from each other and are soft and wet. The softening of this part of the host is apparently due to enzymes secreted by the fungus. Owing to the presence of this softened region and to the tenacity of the central core of the spot it is possible to remove with forceps the entire affected region.

The spot develops rapidly upon a ripe berry. A spot five millimeters in diameter may enlarge to cover a whole berry in about four days.

The Fungus. Either teased or microtome preparations reveal the host cells in the affected region to be filled with the richly branching, many-septate, hyaline mycelium. The region adjacent to the dissolved layer referred to above shows only the tips of the advancing hyphae, with all of the threads arranged with their axes perpendicular to the tangent of the spot at that point. In a median section through a spot the sporodochia may be seen in all stages of development. They are of subcuticular origin and soon become erumpent They vary in shape from columnar with a flat top to broad saucer-shaped. The external portion is sterile and constitutes a kind of peridium, a sterile rim to the disk. This rim may be narrow and even or fairly wide and wrinkled or crimped. The peridium in all specimens may assume a rusty or tan-colored appearance and its component filaments may become rather firmly agglutinated.

The central region is sporiferous and consists of myriads of parallel conidiophores presenting a nearly flat upper surface. Dissection shows the conidiophores to be much branched, never simple, with the spores borne acrogenously and apparently solitary, i.e., not catenulate. The young sporodochia may be hyaline or they may absorb the coloring matter of the ripe berry and present a true ripe-strawberry color. As they age and the spot beneath them becomes tan-colored the sporodochia undergo the same color change. As the sporodochia age they lose, to a large extent, their saucer shape though this loss is really more apparent than real and is due to a heaping up of spores in the center of the sporodochium. In age also the outer row or rows of sterilized conidiophores turn slightly brownish or tan-colored and become rather firmly agglutinated.

The spores are produced in enormous quantities and in humid air may accumulate in the tops of the sporodochia in glistening, globular, slimy drops. They are about twice as long as broad, 6.5 to 8 by 2.5 to 3.5 μ, inequilateral, with one side nearly straight or very slightly concave or convex, the other strongly convex. Both ends are sharply but abruptly pointed. They are hyaline and one-celled.

The mycelium is striking in appearance. The old threads are coarse, 7 μ in diameter, but the main part of the mycelium consists of fine, branch-

ing threads, $2\,\mu$ in diameter. The characteristic mycelium and spore-bearing structures are constant in this disease. The mycelium migrates entirely under the epidermis breaking through to form the sporodochia one or two millimeters from the invasion line of the fungus.

The sporodochia are nearly or quite sessile, are at first circular, flat-topped or a trifle saucer-shaped and with a distinct sterile rim or border.

Isolation was readily accomplished by the usual dilution plating of spores from a sporodochium as well as by direct planting of bits of mycelium upon poured agar plates. Bits of mycelium-bearing tissue taken with aseptic precautions from below the epidermis of a spot invariably gave pure cultures of the fungus.

On bean agar colonies were colorless and circular; after thirteen days they were four to five centimeters in diameter, with the mycelial growth very dense, none of it aerial; the colony border was very even, the sporodochia hyaline to tan-colored and located nearly 1 centimeter back from the margin of the colony.

Inoculations were readily made using either the mycelium or the spores in either wounded or unwounded surfaces. The following note is typical: "Inoculated in wounds on ripe berries April 23 kept in moist chamber at room temperature. On April 26 every berry showed a rotten spot at the point of inoculation and numerous sporodochia."

The following description of a four-days-old spot was made from a typical case on April 27: "Decayed spots from five to ten millimeters in diameter, slightly sunken at the center, tan-colored, verging through light pink near the border to the normal color of the ripe berry. Area throughout and to within about one to two millimeters of the border of the spot studded with sporodochia."

"Sporodochia varying in shape from round, disk-shaped, regular to saucer-shaped and irregular. In color taking the exact color of the supporting tissue so long as this has the normal strawberry color, later changing to tan."

Since it was not feasible to use sterilized berries and since the fungus was naturally so frequently present the controls did not give uniformly negative results. Indeed the controls usually give some, sometimes fairly numerous, cases of disease. The occurrence of the disease was however uniformly much higher in the inoculated berries than in the controls.

The fungus clearly falls within the Tuberculariaceæ-Mucedineæ-Amerosporeæ, and seems with equal certainty to belong to the genus Patellina. This genus, according to Saccardo's Sylloge Fungorum, contains some sixteen species apparently, in the main, saprophytes on wood, bark and so forth. Heretofore none has been reported as of economic significance.

To clarify the consideration of the question of specific position the following table (table 2), has been prepared with the species arranged in order of the minimum spore length given.

The present form, on a basis of spore length alone, can belong only to numbers six to twelve or fifteen or sixteen, and all of these except number eight are excluded on a basis of spore shape. No shape is given for the spores of number eight but if they were crescent-shaped as ours are such a striking character would doubtless have been mentioned. The fungus therefore, appears to be new and we present the following description.

Patellina Fragariæ n. sp.

Sporodochia hyaline to tan- or rose-colored, rarely columnar and flat topped to beaker-shaped, more often saucer or disk-shaped, 120 to 300 μ in diameter, about 120 μ high, surrounded by a peridium of sterile threads and the disk bordered by a sterile frill often revolute or wrinkled.

Conidiophores slender, 1 by 50 μ long, hyaline, abundantly branched, spores solitary, acrogenous.

Spores slightly crescent-shaped, acute at each end, 6.5 to 8 by 2.5 to 3.5 μ.

BOTRYTIS CINEREA

Botrytis cinerea has been observed in great abundance upon Louisiana berries in the field and upon market berries of various origin. A note concerning this disease was published by one of us.[2]

This fungus has since been observed in very destructive form.

SPHÆROPSIS MALORUM

Sphæropsis Malorum was found causing a characteristic blackening or bronzing of the berries. It appears to be of but little economic importance here.

RHIZOPUS NIGRICANS[2]

Rhizopus nigricans is the fungus which at the destination of the berry is most in evidence and the fungus which in reality does most of the damage to shipped berries. The characteristic result is a very soft, moldy berry with the juice leaking abundantly from the container. It is evi-

[2] Stevens, F. L. A destructive strawberry disease. Science, n. s. **39**: 949-950. 1914.

NO.	NAME	SACCARDO Vol.	SACCARDO No.	SPORODOCHIUM Shape	SPORODOCHIUM Color	SPORODOCHIUM Diam	CONIDIA Shape	CONIDIA Ends	CONIDIA Length	CONIDIA Breadth	DIMENSIONS OF CONIDIOPHORES	HOST
						mm			μ	μ	μ	
1	mellea. . . .	22	8818	orbicular or elongate		3-5	globose	rounded	1.5–2	1.5–2	60	Pinus
2	italichroma.	3	3328	orbicular-applanate			elliptical or ovoid		3–4	1.5	8–120 x 1	Melia
3	subconoidea..	22	8819	subhemispherical	black	3.5–5	elliptical	rounded	3–4	2–3	?	Phœnix
4	cinnabarina.	4	3206	patelliform	yellow	0.5	ovoid		3–4.5	2	20 x 1	Platinus
5	Ilicis.	18	5770	orbicular	fleshy, waxy	3.5	elliptical or ovoid		3–4.5	1.5–2.6	25–50 x 1.5	Ilex
6	buellioides. . .	10	8047	irregular	yellow	0.5–1	subcylindrical	obtuse	4–6	1.5–2.5	20–30 x 1	lichens
7	italichroma var. Talae	4	3205	cupulate	green	0.5–0.8	elliptical	acute	5	2	30 x 1	Celtis
8	pallida ..	11	4488	orbicular or irregular	white, rose	0.5–2			5–6	2	100	bark
9	amœna.	16	4256	applanate	red, yellow	0.5–2	cylindrical		5–7	2–3	28 x 32–23	bark
10	bicolor..	10	8048	cupulate	white	0.1	orbicular, elliptical		5–7	2–3	20–45 x 0.5	bark
11	tropicalis	16	4257		rose, red	1-1.5	elliptical, irregular	obtuse	5–10	3–4	15–50 x 1	
12	rhodotephra.	4	3207	orbicular irregular ovoid	white to yellow		ovoid	acute	6	3		Morus
13	pusilla	10	8046	globular or patelliform	white, hyaline to dirty	3.2–3.5	bacilloid		6	1	120–150 x 1–1.5	Fagus
14	Talæ......	16	4255		rose or red	4-7	straight or slightly unequal		10-14	5		Celtis
15	cyathoidea..	4	3208	urceolate			ovoid					Amygdalus
16	leucoloma..	4	3209	cupulate	white		subglobular, ovoid					Ulmus, Lentiscus, Alaternus, Arbutus, etc.
17				disk	hyaline to rose	1.2–3	slightly crescent	acute	6.5–8	2.5–3.5	50 x 1	Fragaria

dent that this fungus does not attack sound berries but is secondary in its nature following one or another of the fungi mentioned above or gaining entrance through some mechanical wound.

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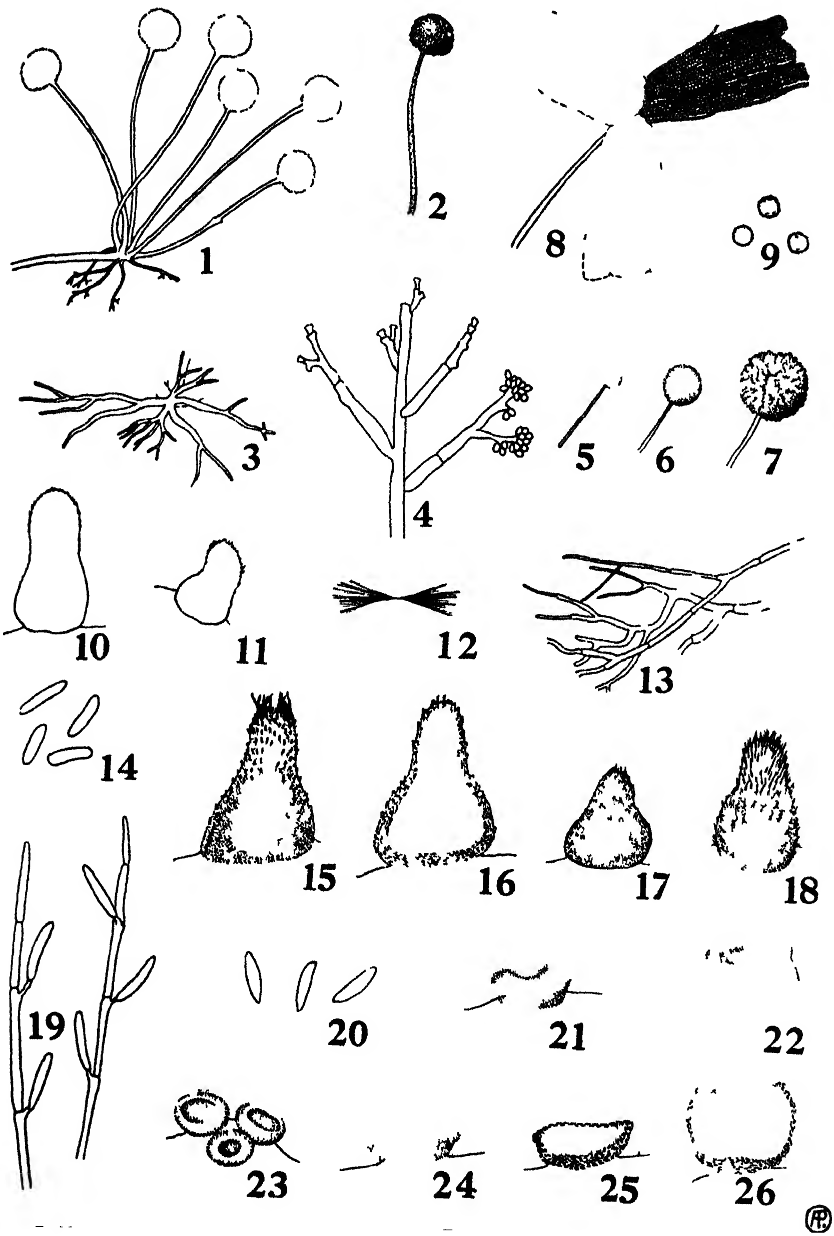
EXPLANATION OF FIGURES

FIG. 1. Rhizopus nigricans showing sporangiophores and rhizoids.
FIG. 2. Rhizopus nigricans showing a single mature sporangium.
FIG. 3. Rhizopus nigricans showing rhizoids.
FIG. 4. Botrytis cinerea showing conidiophores and conidia.
FIGS. 5, 6, 7, and 8. Aspergillus showing stages in the development of a conidial head.
FIG. 9. Aspergillus showing spores.
FIGS. 10 and 11. Sphæronæmella Fragariæ. Outline drawings of perithecia.
FIG. 12. Sphæronæmella Fragariæ showing form of crystals found in pure cultures on agar.
FIG. 13. Sphæronæmella Fragariæ showing mycelium.
FIG. 14. Sphæronæmella Fragariæ showing conidia.
FIG. 15. Sphæronæmella Fragariæ showing perithecium.
FIG. 16. Sphæronæmella Fragariæ showing a section through a perithecium.
FIGS. 17 and 18. Sphæronæmella Fragariæ showing perithecia.
FIG. 19. Patellina Fragariæ showing conidiophores.
FIG. 20. Patellina Fragariæ showing conidia.
FIGS. 21, 22, 23 and 24. Patellina Fragariæ showing sporodochia.
FIGS. 25 and 26. Patellina Fragariæ showing section through sporodochia.



STEVENS AND PETERSON STRAWBERRY FUNGI

COTTONY ROT OF LEMONS IN CALIFORNIA[1]

CLAYTON O. SMITH

WITH FIVE FIGURES IN THE TEXT

The decay of lemons, commonly known as cottony rot or white mold, may be found frequently in the lemon packing houses of California during the season from January to May. The loss here in fruit during the time of curing is often considerable.

The fungus causing the trouble is a species of Sclerotinia, and its occurrence on lemons has been discussed[2] in California Experiment Station bulletins and local horticultural papers. From spore measurements and other morphological characters the fungus has always been referred to the species, *Sclerotinia libertiana* Fuckel. To determine this point more fully, cultures supposed to be of this species were secured from different sections of the United States through the courtesy of several of the State Experiment Stations. Cultures were also secured from different localities in California where this or a very similar fungus was found attacking different plants. Results of inoculations of these strains on various hosts are summarized under artificial inoculations, table 1, and seem to show that the cottony rot fungus is identical with *Sclerotinia libertiana*.

Among species of Citrus, the fungus is found to attack the fruit of the lemon in the packing house, the twigs of oranges and lemons in the orchard, and rarely the blossoms of lemons. The chief loss is in the packing house where the fruit remains from one to two months before being shipped. The tents or rooms where the fruit is stored during the curing process are kept in a somewhat humid condition to prevent wilting of fruit. This condition is favorable also for the spread of the fungus. The spores from which the initial infection takes place are brought from the orchard into the packing house on the fruit, and are not all killed by the present methods of disinfecting the fruit as it passes through the lemon washer. The spores are given off from the apothecial stage of the fungus which occurs in the orchard under the vetch and other cover crops. From the initial infection a large amount of fruit may be infected by contact. This usually com-

[1] Paper No. 26, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

[2] California Agr. Exp Sta. Bul. 218:1123. 1911; California Cultivator **35**:No. 9. 1910.

FIG. 1. Apothecia of Sclerotinia. Developed from sclerotia growing in a pure culture which was isolated from a diseased orange branch

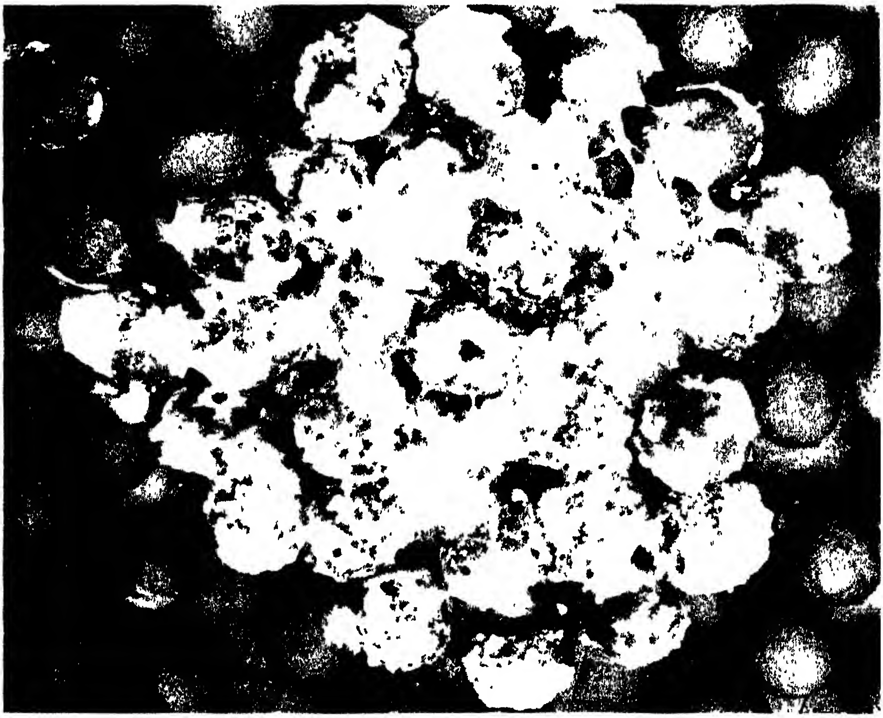


FIG. 2. Cottony rot as developed in packing house tray during storage.

prises most of the fruits in the half box where the rot is present (fig. 2). The disease sometimes spreads to other boxes of the stack, thus affecting a large amount of fruit.

The decay on the fruit is characterized by a white cottony-like mycelial growth that spreads over the surface of the fruit (fig. 2). The interior of the fruit after a time becomes diseased and the entire structure breaks down

FIG. 3. Natural infection of Sclerotinia in the fruiting wood of Eureka lemon.

into a more or less soft decay. After a time sclerotia are produced, but no conidial spores of this fungus have ever been found, either on the decaying fruit or in cultures.

The disease has been found in citrus seed-beds attacking both the sour- and sweet-orange stock. The shaded conditions here are favorable for the development of the fungus. The trees are grown close together and

usually small areas of them, comprising from six to a dozen or more trees, may be affected. The disease, however, is not regarded as a serious seed-bed trouble.

Nursery and orchard trees occasionally may be attacked. Small trees that have received winter protection with cornstalks are especially sus-

FIG. 1. Artificial infection on citrus twigs from inoculation with cultures of Sclerotinia. *A*, Orange twigs artificially infected with a pure culture of the avocado stain of Sclerotinia. *B*, Infection on lemon secured with a culture of Sclerotinia isolated from Eureka lemon twig. *C*, Infection secured with a culture of Sclerotinia, isolated from alfalfa stem, inoculated on lemon stem at leaf scar, the leaf being plucked immediately preceding inoculation. No other injury was made. Inoculation protected with waxed paper. *D*, Inoculation at leaf scar of lemon with a culture of Sclerotinia isolated from celery. *E*, Infection on lemon secured with a culture of Sclerotinia grown from sclerotia on soil under a vetch cover crop.

ceptible. On the larger trees the smaller twigs or more rarely larger water sprouts may be killed. The orchards affected are more frequently found in localities where and in seasons when the temperature has caused injury from frost.

The affected twigs show dead, dried, rolled-up leaves that remain attached for some months. The affected bark becomes a cinerous color and

at length fibrous. Gumming takes place especially near the margin of the infection and with the appearance of gum, further growth of the mycelium in the tissue is usually checked. The infections may extend one or two inches along the twig, gradually surrounding and killing it. While the fungus usually completely girdles the twig, it sometimes happens that the weather or other conditions become unfavorable and the fungus dies out without completely killing the twig. The disease on citrus twigs is rather of scientific interest than of economic importance, as the affected twigs are readily cut out at pruning time.

Under favorable conditions, the blossoms may be attacked and thence the fungus spreads into the fruiting twigs. The fungus probably starts in the decadent petals which may remain attached for some time. The blossoms of the lemons are produced in dense clusters, and a mass of these collapsed, partly dead petals give a favorable medium in which the fungus may become established as a saprophyte.

Sclerotinia libertiana is not restricted in California to Citrus as a host, but is found occasionally attacking other trees, plants, vegetables, green manure cover crops and weeds. It is at times parasitic on the blossoms of apricots,[3] attacking them while still enclosed by the calyx cup of the blossom. It was found, by H. S. Fawcett, of this Station, attacking the twigs of avocado, *Persea gratissima*, and is believed to have first gained its entrance through the collapsed petals in a manner similar to the attack of the lemon. The following are the hosts in California known to be affected by *Sclerotinia libertiana*, or a species closely resembling it morphologically and pathogenically: lemon fruits, twigs and blossoms, orange twigs, apricot blossoms, rarely avocado twigs, lettuce, tomato, celery, cucumber, eggplant, vetch, nettle (*Urtica urens*), and prickly lettuce (*Lactuca scariola*). These last two are common weeds in citrus orchards.

It is probable that the cottony rot has been gradually increasing with the growing of winter cover crops, especially of vetch. The dense growth of vetch affords a suitable place for the fungus to develop on the lower and more shaded parts of the plant. Here sclerotia are produced in abundance preparatory for the spore stage of the coming year. With the continued use of cover crops and mulches in the citrus groves, it is probable that the fungus will continue as an important factor in the decay of lemons.

The apothecial stage may be found from October to April under the cover crop or volunteer growth in citrus orchards, more especially those of lemon orchards. The fruiting bodies seem to be more numerous in or on the sides of the irrigation furrows, although they may occur at any place on the ground in the orchard.

[3] California Agr. Exp. Sta. Bul. 218:1097. 1911.

Artificial inoculations made on lettuce plants, after heading, with cultures of Sclerotinia, isolated from lemon twigs and fruit, showed characteristic softening and rotting under moist chamber conditions, in three to seven days. Spores from apothecia found in the orchard and applied to lettuce heads with a camel's hair brush, failed to produce infection after two weeks' time under moist chamber conditions, while inoculations with cultures made from such apothecia showed positive infection in five to seven days. The fungus, Sclerotinia, was again recovered from the above infections.

Artificial infection of lemons can be produced readily in a moist chamber with *Sclerotinia libertiana*: (1) by placing the mycelium or sclerotia into the tissue through a puncture or injury; (2) by placing mycelium on the uninjured surface of the fruit; (3) by placing a piece of an apothecium in the tissue through a puncture or injury; (4) by atomizing spores on the surface, in which case infection occurs only at the stem- and blossom-ends and at points in contact with moist chamber; (5) by inoculating the stem- and blossom-ends with mycelium of the fungus. In this case, infection develops within two weeks' time.

Inoculations on lemon fruits have been made repeatedly in moist chambers with the mycelium from pure cultures of *Sclerotinia libertiana* secured from several different sources. These are summarized in table 1. Orange fruits appear also to be equally susceptible, but have not been so thoroughly tested.

Inoculations with spores of the cottony rot fungus have been tested in different ways. Experiments in atomizing lemon fruits in a moist chamber, usually result only in the production of infections at the stem- and blossom-end. The germ tubes seem to be unable to penetrate the uninjured tissue. This fact is further substantiated by placing apothecia, spore-bearing surface down, in drops of sterilized water, or in drops of dilute prune juice on the surface of fruits. No infection takes place on the uninjured surface of the rind. An apparent exception took place in one experiment in atomizing fruit picked after several days of rain. This fruit was first sterilized with 4 per cent formalin which was rinsed off. The atomized fruit was kept in a moist chamber out-of-doors during the time of the experiment where the temperature was somewhat cooler than in the laboratory. In five days the five lemons were found to be infected at points where they were touching each other and at the stem- and blossom-ends. The probable explanation of this infection is believed to be the more susceptible condition of the fruit following cool, rainy weather.

Lemons have been inoculated with the spore dust from apothecia growing in a closed vessel. It is a well established observation that apothecia growing in a closed vessel will eject their spores as a dust-like puff. Lemons

were first moistened with water and then infected by allowing this dust to come in contact with the fruit which was then placed in a moist chamber and atomized with sterile water. Infection took place at the stem-end of fruits.

TABLE I.

Summary showing the results on various hosts of artificial inoculations made with the mycelium of various strains of Sclerotinia for the most part supposed to be Sclerotinia libertiana

SOURCE OF CULTURE[1]	LEMON FRUIT	LEMON TWIGS	ORANGE TWIGS	AVOCADO TWIGS	ENGLISH WALNUT TWIGS	APRICOT TWIGS	PEACH TWIGS	PLUM TWIGS
Lettuce, California ..	+	+	+	+	+		−	−
Lettuce, North Carolina.	+	+				−	−	−
Lettuce, Maine	+	+	+			−	−	−
Lettuce Wisconsin	+	+			+	−	−	−
Ginseng,[2] Cornell University	+	+	+	+			−	−
Snapdragon, Maine	+	+	+	+	+		−	−
Beans, Maine	+	+	+	+		−	−	−
Lemon twigs, California	+	+	+	+	+	−	−	−
Lemon fruits, California	+	+	+					
Alfalfa, Oregon	+	+	+					
Avocado, California	+	+	+	+	+			
Cucumber, Oregon	+	+	+	+	+			
Apothecia, lemon grove, California	+	+	+	+		−	−	

[1] The author wishes to acknowledge the courtesy of the Experiment Stations of the states indicated in sending him cultures of Sclerotinia.

[2] The Sclerotinia of ginseng has recently been proved to be identical with *Sclerotinia libertiana* Rosenbaum, J. Pathogenicity and identity of *Sclerotinia libertiana* and *Sclerotinia smilacina* on ginseng. Jour. Agr. Research **5**: 291. 1915.

Soaking lemons for 36 hours in water in which spores of the cottony rot fungus were placed, gave negative results. Puncture inoculation in the tissue of lemon fruits with small pieces of an apothecium almost without exception produced infection.

The artificial infections on the lemon fruits with the different strains of Sclerotinia as indicated in table 1, showed the same general characteristics with the exception of the one from alfalfa. The fruits when inoculated with the cottony fungus show at first a discoloration and a slight softening of the rind. The color changes from the usual lemon color to that of straw (D).[4] No aerial mycelial growth takes place until from one to two weeks. At length, however, a dense white cottony growth with sclerotia covers the infected lemons.

[4] Dauthenay, Henri. Repertoire de Coulours, p. 31, No 3.

The Sclerotinia from alfalfa is commonly referred to as *S. trifoliorum*. The artificial inoculations with this fungus on both the lemon twigs and fruit were much slower in developing than with the other strains of Sclerotinia. In the inoculated lemons the decay not only starts more slowly, but also shows a different color development in the affected tissue before the growth of the aerial mycelium. This color instead of being straw color, as described above, is a chocolate color (D).

In table 1, positive results are shown for all the artificial inoculations on the twigs of lemon with the various strains of Sclerotinia tested. Similar positive results are shown for many of these strains on orange twigs. The others were not tested on orange twigs, but would doubtless have given positive results. No successful inoculations were made on apricot, olive, peach or plum twigs. Positive results were secured from inoculations made on the English walnut and avocado. In these inoculations the infected bark became dark-colored, and at length fibrous. In all the artificial inoculations of the twigs, the mycelium of the fungus was placed between the loosened bark and wood and the injury wrapped with paraffin paper.

Avocado twigs have been successfully infected artificially with cultures of *Sclerotinia libertiana*, but are much more resistant than those of Citrus. In many cases the infection developed slowly and the fungus was only able to penetrate a short distance into the healthy tissue. The infected avocado tissue is readily recognized by its darker color. In more succulent or less vigorous twigs certain of the stains showed greater virulence and completely girdled the twig in two weeks' time. These infections are accompanied by the deposit of a white powdery substance on the surface of the twig (fig. 5). This deposit seems frequently to follow any sort of injury.

The English walnut is strongly resistant but successful inoculations on the less vigorous twigs have been made with certain of the strains of Sclerotinia (see table 1). It is of interest to note that *Sclerotinia juglandis* (Preuss) is described[5] as rotting the cotyledons of walnuts. From our present understanding of the hosts that *Sclerotinia libertiana* can attack, it would not be surprising if these two fungi proved to be identical.

The control of this decay can probably be best accomplished by the use of disinfectants in the lemon wash water. Copper sulphate 0.02 per cent is very generally used at present in the control of the brown rot, *Pythiacystis citrophthora*. In general practice, however, several of the common decays, including that of the cottony rot, are not so well held in check by the methods now in practice. This is thought to be partly due to several faults in the present methods. (1) All the wash waters contain carbon-

[5] Rabenhorst Krypt. Fl. Deut. Oesterr. U. d. Schw. Ascomyceten 3:810. 1896.

ates in solution which unite with the copper sulphate as a basic copper carbonate, thus lowering the germicidal strength of the solution. This can be overcome by partly neutralizing the alkalinity with an acid such as

FIG. 5. Artificial infection of avocado with a culture of Sclerotinia isolated from snapdragon.

sulphuric acid. (2) The other factor which lowers the strength of the copper sulphate solution is the addition of hydrant water to replace that removed by the lemons in washing. This not only dilutes the germicide, but also adds more alkali thus causing more copper carbonate to be formed. This last difficulty can be overcome by adding copper sulphate solution, properly made, to the washing tank, to replace the water removed. Investigations of more efficient disinfectants in lemon wash waters, are being made in greater detail by E. E. Thomas, of this Station.

In some preliminary studies there were indications that the use of a 25 per cent solution of alcohol preceding the use of the copper sulphate disinfection would give greater efficiency. This was tested to a limited extent in a packing house. Little cottony rot, however, developed in the untreated fruit, so the results were not as conclusive as could have been desired. No cottony rot developed in the seventy-eight boxes treated with 25 per cent denatured alcohol and then washed in acidified copper sulfate solution. In the check on the experiment with seventy-eight boxes washed in untreated hydrant water, one box showed cottony rot. In the experiment where the water was two-thirds neutralized with sulphuric acid before the addition of the copper sulphate to make a 0.02 per cent solution, there was one box that showed cottony rot out of the seventy-eight boxes treated.

The results suggest that further experimentation may prove that alcohol has some beneficial results in separating the spores from each other so they may be more readily acted upon afterward by the germicide.

GENERAL CONCLUSIONS

Research upon this disease has established the following facts.

1. Repeated inoculations have proved that the cottony rot is caused by a species of Sclerotinia, probably *Sclerotinia libertiana.*

2. That this fungus not only attacks the lemon fruit but also the twigs of mature and small orchard trees, nursery stock and sweet- and sour-orange seed-bed stock.

3. The hyphae of the vegetative stage of the fungus are able to enter and destroy a perfectly sound lemon at any point off contact, no abrasion being necessary.

4. Several strains of *Sclerotinia libertiana* from different localities of the United States, when inoculated in the fruit and twigs of lemons are pathogenic, showing infection similar in all characters to that of the lemon cottony rot fungus isolated from fruit and twigs of Citrus.

5. Attempts to inoculate the healthy uninjured skin of a lemon with spores applied with an atomizer over the entire fruit have failed, except

at the stem- and blossom-ends and rarely at points where two fruits are in contact.

6. The fungus has repeatedly been carried through its entire life cycle from ascospore to ascospore. No other spore stage has been observed.

7. Strains of Sclerotinia isolated from bean, cucumber, lettuce, vetch, wild lettuce (*Lactuca scariola*), twigs of Citrus, avocado, tomato, eggplant, appear to be identical with the organism causing decay of lemon fruits known as the cottony rot.

8. No more satisfactory method of control has been discovered than that now being used, a 0.02 per cent solution of copper sulphate in wash water, but certain improvements in method are suggested.

WHITTIER, CALIFORNIA

THE FORMATION OF PARENCHYMA WOOD FOLLOWING WINTER INJURY TO THE CAMBIUM

A. J Mix

WITH THREE FIGURES IN THE TEXT

The formation of a thin-walled parenchyma as an interruption in the normal wood ring has been mentioned by various European writers. T. Hartig[1] who calls tissue aggregations of this sort "zellgange" speaks of their occurrence in the basal portion of the trunk of birch and hazel. De Bary[2] designates as "markflecke" areas of parenchyma tissue occurring in many woods both at the boundary and in the interior of the annual ring. He considers them hypertrophies of the medullary rays, but like Hartig, seems to believe that they occur normally in certain trees. Later authors recognized a pathologic condition. R. Hartig[3] and von Tubeuf[4] describe and figure parenchyma tissue as formed following lightning injury to the youngest wood elements of firs during the vegetative period Sorauer[5] mentions the phenomenon in several connections. It occurs in the case of edema of currant and gooseberry (pp. 335 336), where it is initiated by injury to the cambium; it may be observed in regenerative tissue formed after knife slits through the bark and cambium (pp. 766-768), after girdling (pp. 794–800), and after bending which has been severe enough to separate bark from wood (pp. 800-804). It is described and figured (pp. 614–621) as consequent to both natural and artificial frost injury to young oaks occurring during the early vegetative period, and the same author[6] states that he has observed parenchyma wood as the first tissue laid down in the spring, in the case of trees susceptible to injury from cold.

[1] Hartig, T. Vollstandige naturgeschichte der forstlichen culturpflanzen Deutschlands. pp. 228, 326. 1851.

[2] De Bary, A. Vergleichende anatomie der vegetations-organe. pp. 507-508. 1877.

[3] Hartig, R. Untersuchugen uber blitzschlage in waldbaumen. Forstl. Naturw. Zeitschr. **1897**: 108, 118.

[4] Tubeuf, K. von. Ueber sogennante blitzlöcker im walde. Naturw. Zeitschr. Land- u. Forstw. **4**: 344–351. 1906.

[5] Sorauer, P. Handbuch der pflanzenkrankheiten. **1**: 335–336, 612–621, 766–768, 794–800, 800–804. 1909.

[6] Sorauer, P. Experimentelle studien über die mechanischen wirkung des frostes bei obst und waldbäumen. Landw. Jahrb. **35**: 469–525. 1906.

Sorauer explains this formation of parenchymatous tissue instead of normal thick-walled xylem elements as the result of lessened pressure on the cambium. This lessened pressure or loosened bark tension is brought about by the freezing process and one or both of two factors may be the immediate cause: clefts formed in the bark tissue, or a loss of bark elasticity consequent to too great tangential stretching. In the last case mentioned above the only factor which can be operative in lessening the bark pressure is a "stretching and loosening" of the cambial area brought about by freezing. It is stated as improbable that this tissue formation as the result of frost injury ever occurs in any but young and nearly herbaceous stems.

Kienitz[7] and Grossenbacher[8] observed parenchyma wood formation following injury by insect larvae mining in the cambium of various trees.

The writer has observed the formation of parenchyma wood in two cases, in which it followed what was, apparently, an injury to the cambium due to freezing while in the rest condition.

The first case was found in Clinton County, New York, in the spring of 1915. A number of 2- to 3-years-old apple trees in several orchards were observed on June 3 to be in an injured condition. The tops appeared dead, the branches and the upper trunk dry and shrivelled, but the bark, cambium, and sapwood appeared bright when cut across with a knife. The bark of the lower trunk, from the surface of the ground up for a distance of about one foot, was turgid and normal in color and general appearance. From various points in this apparently healthy area, green branches were emerging. On being cut into, the bark of this portion of the trunk appeared bright colored and normal, but a grayish brown discoloration was evident in the outer sapwood. This discoloration did not extend below the level of the surface of the ground. Closer examination of the discolored portion showed a zone of browned tissue in the outer sapwood, outside of which a zone of normal colorless wood was being laid down. Under the microscope the browned area was seen to consist of parenchyma wood. Internally, these trees showed some browning in the wood cylinder, especially in the medullary rays.

The above-described injury was attributed to winter-injury for the following reasons: (1) It was confined to one variety, the Rhode Island, a variety which according to the best local authority is not hardy in Clinton County nor in northern Vermont. One grower who had visited several orchards in northern New York and Vermont reported additional cases

[7] Kienitz, M. Die entstehung der "markflecke." Bot. Centbl. **4**: 21-27, 56-61. 1883.

[8] Grossenbacher, J. G. Medullary spots: A contribution to the life history of some cambium miners. New York Agr. Exp. Sta. Tech. Bul. **15**: 49-65. 1910.

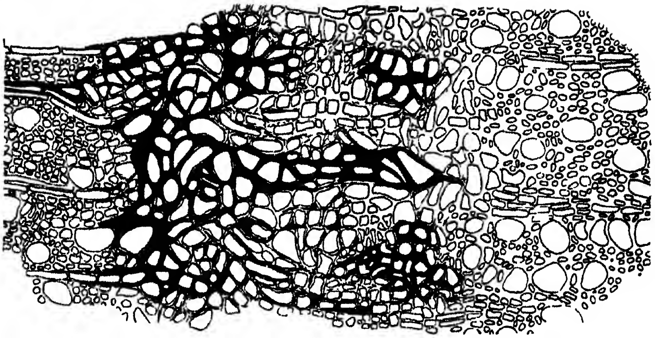


FIG. 1. Longitudinal section of injured zone in young Rhode Island tree, showing parenchyma wood between two layers of normal wood. The intercellular substance is represented by black shading Outlined with a camera lucida. × 50.

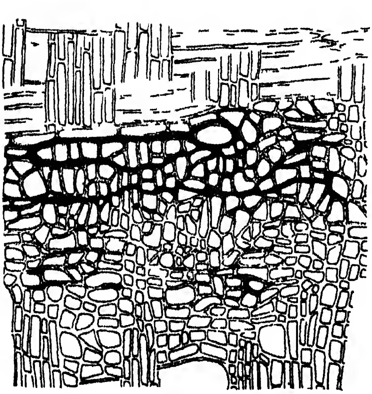


FIG. 2. Cross section of the same tissue shown in figure 1. Outlined with a camera lucida. × 50.

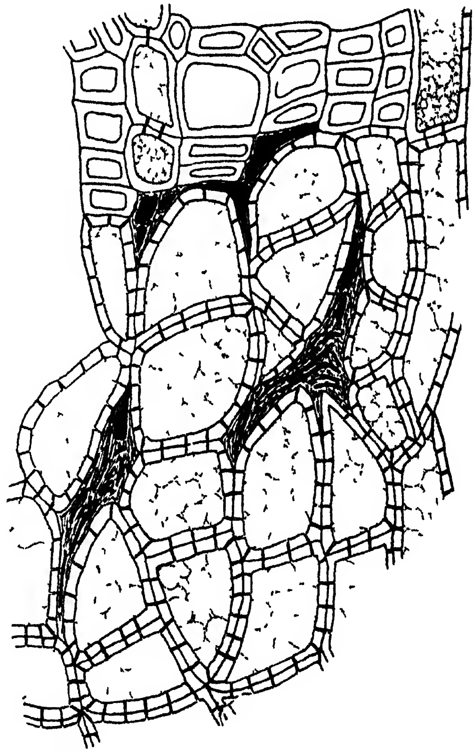


FIG. 3. Cross section through parenchyma wood zone, enlarged, showing origin of yellow substance from injured collapsed cambium cells. Note the remnants of cell membranes. Outlined with a camera lucida. × 350.

of the injury, all to the Rhode Island variety, and stated as his experience that it was not uncommon following severe winters. (2) The largest number of injured trees was found in an orchard, in which the trunks had been surrounded by tar-paper protectors during the winter, a practise which is considered by some orchardists to be conducive to winter injury.

The trees which were allowed to remain during the summer formed a new top from the new branches mentioned above. Internally, the trunks presented the appearance known as black heart, a fairly common type of winter injury in northern localities, in which a sound wood-ring surrounds a cylinder of dead, brown and brittle tissue.

The second case of parenchyma wood formation was even more plainly consequent to winter injury. During the winter of 1914–1915, in the course of some studies on winter sun-scald, a number of young trees were watched carefully for the occurrence of natural injury to the cambium. These trees stood in the University orchard at Ithaca, N. Y., were from six to eight years old and of the Northern Spy and Gano varieties. In the latter part of February several of the trees showed injury to the cambium and bark on the southwest side of the trunk.

In artificial freezing experiments (to be reported elsewhere) it was found that the portion of the cambial area nearest to the xylem, in other words the youngest xylem elements, was the area first susceptible to injury. More severe injury involved more of the cambial area up to its complete browning. Similarly, this natural injury varied in different cases from about 10 to 50 per cent of the cambial area, the injury always being on the side next the xylem. The injury was evidenced by a browning of the cell contents, the cell walls remaining colorless. There was no injury to the xylem itself, but there were a considerable number of cells in the cortex showing browned cell contents. There were no clefts in the bark due to separation of the tissues such as Sorauer describes for spring frost injury.

On October 30, 1915, these trees were again examined. The injury could only be detected by removing a cutting extending into last year's wood. It appeared as a brown line between the annual rings of 1914 and 1915. Microscopically, cross and longitudinal sections through this brown line showed that the first wood formed last spring was a comparatively narrow zone of parenchyma wood, that normal xylem was soon laid down outside of this zone, and the remainder of the wood-ring was normal.

The tissue described by Sorauer as "parenchymholz" which is here translated as parenchyma wood, is a tissue in which the normal xylem elements—wood fibers and vessels, are not recognizable. In their place has been formed an aggregation of irregular but nearly isodiametric cells,

with comparatively thin, pitted[9] walls and large lumina. The cells are, aside from their form, apparently normal; there is no discoloration in cell walls or contents; they are especially rich in starch. The medullary rays can be traced into this parenchyma zone and are seen to become enlarged and spread out tangentially (figs. 1 and 2).

At various places throughout this tissue there occur intercellular areas occupied by a yellowish brown amorphous substance. At first glance this appears like a browning in the cell walls, and at places the walls seem to be swollen as well as browned, but more careful examination shows that the cell walls are normal and that the yellowish brown substance lies pressed between them.

An attempt was made to determine the nature of this substance by microchemical tests but nothing definite was learned. It does not appear to be a gum like that occurring in gummosis of Prunus and Citrus, nor to be of the nature of wound gum. It does not swell nor dissolve in water, is not soluble in alcohol, nor in alcohol after treatment with potassium chlorate; colors brown with iodine, red-brown with chlor-iodide of zinc; stains readily and more deeply than the walls with various stains—safranin, Delafield's haematoxylin, fuchsin, Bismarck brown and methylene blue.

This yellowish brown substance indeed resembles very much the amorphous brown cell contents of cells injured by freezing, and it is believed to be merely the remains of the originally injured cells, collapsed and crowded together by the growth of later-formed cells. A glance at figure 3 will make this clear. Sorauer found fragments of the cell membranes in the yellow substance. The writer believes he has confirmed this.

It is to be pointed out that in these observed cases of parenchyma wood formation there were no bark clefts nor bark injury other than the killing of occasional cells; that any lessened tension which may have occurred could be due only to partial injury to the cambial area. Further, the tissue was formed in stems which were not "young and nearly herbaceous," and it is doubtful how much of a factor loosened bark tension could be in these cases. However, what stimulus induces the formation of this parenchyma tissue, is not apparent. It is seen to have resulted from an injury by freezing to the cambial area, in which the browning in no case involved more than the half of that area next to the xylem. Whether there was injury to cells which did not show browning could not be determined.

AGRICULTURAL EXPERIMENT STATION
GENEVA, NEW YORK

[9] Mention of the pitted condition of the walls is made by T. Hartig and De Bary, and not by the later writers, though it appears in their figures.

PHYTOPHTHORA INFESTANS ON TOMATOES[1]

F. D. Kern and C. R. Orton

With Two Figures in the Text

An unusual outbreak of *Phytophthora infestans* on tomatoes occurred in central Pennsylvania in 1915. It was especially notable in the experimental plats of the Pennsylvania State College. Inasmuch as it has not been reported previously on tomatoes from Pennsylvania it seems that a brief account of this outbreak may be interesting to pathologists.

That Phytophthora sometimes causes heavy loss to outdoor tomatoes has been recorded by Smith[2] in California and Reed[3] in Virginia, but a search through the American literature shows that the disease has been uncommon and not severe on tomatoes except occasionally in the above mentioned states.

In America the Phytophthora disease has been reported on tomatoes also from Maine and Connecticut by Thaxter[4] and from Massachusetts by Stone.[5] Clinton[6] however, says that the disease is evidently rare in Connecticut. Stone states that in 1905 the disease was prevalent in Massachusetts.

In Europe it is reported on the tomato by numerous authors. The disease has been reported from New Zealand by Anderson[7] and Cobb[8] states that it injures tomatoes in Australia. Apparently the Phytophthora occurs infrequently on tomatoes wherever this crop is grown near potatoes infected with the fungus.

[1] Contribution from the Department of Botany, Pennsylvania State College, No 5

[2] Smith, R. E. Tomato diseases in California. California Agr. Exp. Sta. Bul. 175 9–15 1906.

[3] Reed, H. S. Tomato blight and rot in Virginia. Virginia Agr. Exp. Sta. Bul. 192. 1911.

[4] Thaxter, Roland. Diseases of tomatoes. Ann. Rept. Conn. Agr. Exp. Sta. **1890**: 95. 1891.

[5] Stone, G. E. Downy mildew of tomato. Ann. Rept. Mass. Agr. Exp. Sta. **18**: 115. 1906.

[6] Clinton, G. P. Notes on parasitic fungi. Ann. Rept. Conn. Agr. Exp. Sta. **1903**: 365. 1903.

[7] Anderson, S. F. New Zealand Dept. Agr. Bul. 33: 18–19. 1913.

[8] Cobb, N. A. Agr. Gaz. N. S. W. **13**: 410–414. 1902.

That "late blight" is sometimes much more serious on tomatoes than on potatoes in the same locality is explained by Reed[9] on the ground that in such localities early varieties of potatoes are grown principally and that the period of greatest susceptibility for the potato is passed before weather conditions are favorable for its appearance.

The exact date of the first appearance of *Phytophthora infestans* at State College in 1915 is unknown but it was first recorded by the writers on potatoes August 23. It was probable at that time that it must have been evident at least a week previous to this date and perhaps sooner. It undoubtedly appeared on the tomatoes at the same time but was not actually observed until three or four days later. At that time it was wide spread in one of the plats where hybridizing experiments were being conducted on Yellow Pear and Enormous varieties. In this plat both

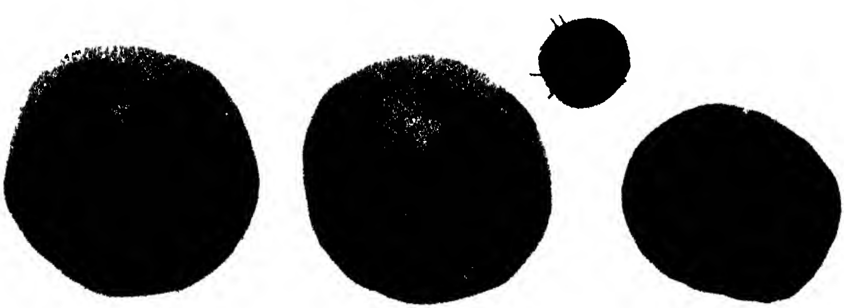


FIG. 1 Phytophthora infestans on tomato fruits The grayish areas show well developed conidia.

varieties as well as the crosses were badly infected. In the larger plats, where one acre was divided into four plats, used for testing varieties of tomatoes for yield, and so forth, the disease was first noticed on plat 1 September 1. On September 4 it had progressed over plats 2 and 3 and on September 10 the entire field was badly infected and practically destroyed.

According to Professor Myers, who had charge of the tomato experiments, those varieties which were most susceptible to Septoria blight were least affected by Phytophthora blight. Unfortunately no records were kept on the resistance of varieties to Phytophthora but all of the 39 varieties grown in the acre plat were affected and the crop was almost a total loss.

[9] Reed, H. S. Does Phytophthora infestans cause tomato blight? Phytopath **2**: 250 252. 1912.

The fungus appears to attack leaves, stems and fruit with about equal virulence. It was especially conspicuous on the fruits where the grayish patches of conidiophores stood out plainly against the darkened water-soaked areas (fig. 1). In connection with the appearance of the fungus on the stems it was especially noticeable that wilting did not occur in the distal portions until considerable time after a localized attack. The tissues might be collapsed entirely for a region of two or three inches on a stem (fig. 2), and yet the leaves on the portion above might show no indication of the presence of a disease for two or three days.

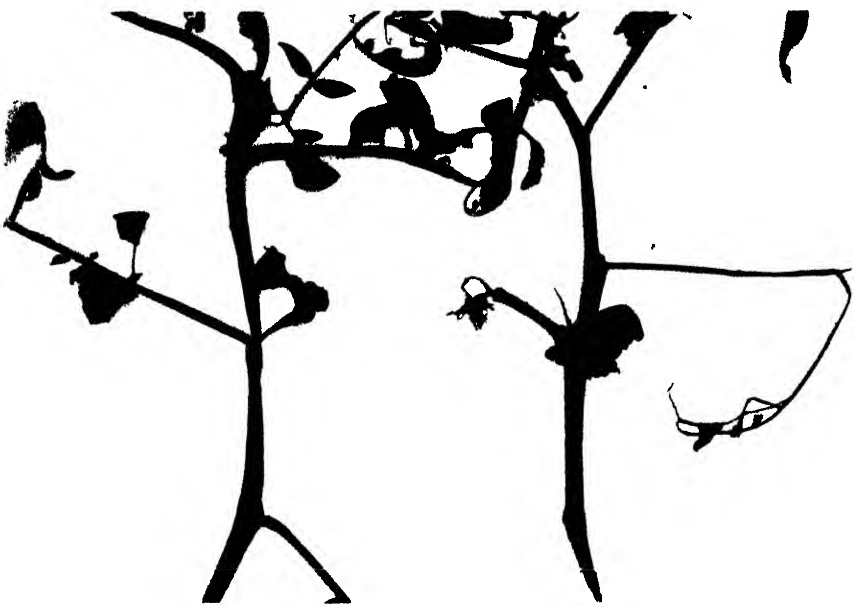


FIG. 2. Phytophthora infestans on the stems of tomato. On the left the stem tissues have collapsed but the leaflets above have not yet wilted.

A comparison of the yield this year with any normal year might be expected to show the extent of the loss due to the fungus. Such a comparison, however, would not be fair for owing to weather conditions and the unusual growth of the plants the yield would have been much decreased in 1915 without any blight whatever. The cool moist weather favored the production of heavy foliage and interfered with pollination to some extent so that the setting of the fruit was far less than in the previous season. What the blight did do was to affect so much of the fruit which did set that there was obtained from the Experiment Station grounds practically nothing of marketable value.

The possible connection between the weather conditions and an outbreak of a disease such as just described makes an interesting subject for consideration. This phase has been made the subject of special investigation by one[10] of the writers and it is not intended to discuss the matter here. It may be pointed out that the two features in which the weather varied in our region during the growing season of 1915 were the unusual low temperature and the excessive rainfall.

PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNSYLVANIA

[10] Orton, C. R. Meteorology and late blight of potatoes. (Abstract) Phytopath. 6: 107. 1916.

OBSERVATIONS ON FIRE BLIGHT IN THE YAKIMA VALLEY, WASHINGTON[1]

J. W. HOTSON

WITH PLATES VII AND VIII

During the spring and summer of 1915 several very peculiar conditions were observed in the study of fire blight in the Yakima Valley, Washington. Some of these were so radically different from what has been generally accepted regarding the way the blight organism works that careful observations and cultures were made in order to obtain as much light as possible on the situation. Fire blight on the fruit of Royal Ann cherries has already been reported.[2]

FIRE BLIGHT ON PEAR LEAVES[3]

An interesting case of leaf infection has been repeatedly observed on different varieties of pears, especially the Bartlett. This was particularly evident after a rain of which there were two unusually heavy ones during the early summer. This condition on leaves was first observed towards the end of June but it undoubtedly existed earlier in the spring than that. The infected leaves turn brown in sections, the brown areas always including a portion of the margin of the leaf. In some cases only a small portion of the leaf, extending in from the margin a quarter or half an inch, is affected while in others the affected area extends to the midrib, and in still others spread nearly or completely over the whole leaf. A few of these leaves are illustrated in plate VII, figure 1. In only a small number of instances were the leaves completely discolored or any evidence shown that the infection ran back through the petiole into the branch.

At first this condition was considered a sun-scald, but occasionally leaves were brought to the laboratory with exudate on them, particularly, as has been said, after a rain. On one occasion, July 7, leaves showing exudate were examined in conjunction with F. D. Heald, pathologist of the

[1] Abstracted in Phytopath. 6: 115–116. 1916.

[2] Hotson, J. W. Fire blight on cherries. Phytopath. 5: 312–316. 1916.

[3] Since submitting this article for publication the writer's attention has been called to a recent bulletin by F. D. Heald entitled Preliminary note on leaf invasions by Bacillus amylovorus. Washington Agr. Exp. Sta. Bul. 125.

State College of Washington. A microscopic examination of this exudate showed that there was a large number of bacteria present, which suggested fire blight. To determine definitely if these discolored areas were the result of *Bacillus amylovorus*, tube cultures were made from the exudate and also from infected pieces of leaves. The bacteria that appeared in these cultures were then transferred to green pears which had previously been sterilized and treated in a manner similar to that previously described.[2] As a result of these experiments, over ninety per cent of the cultures taken from the exudate readily produced the characteristic fire blight colonies on sterilized pears. Of the cultures taken from leaves that showed no exudate a much smaller proportion of infections was obtained. A large number of gross cultures was also made of discolored leaves showing no exudate. In these cases a portion of the leaf was transferred directly to the sterilized pears in moist chambers. Of these less than ten per cent indicated the presence of living organisms.

The organisms in the leaves apparently soon die, probably as a result of the action of the direct sunlight combined with the heat, which often reached 45 to 50°C. on a hot day. This would account for the low percentage of living organisms found on these leaves and also for so few instances of twig infection as a result of the organisms working back through the petiole.

As far as the writer is aware this represents an entirely new mode of attack by the fire blight organism. It would appear that the bacteria gain entrance either at the margin or through punctures in the leaves near it. The fact that invariably a portion of the margin is included in the discolored area would tend to point to it as the place of entrance. This theory is emphasized by the fact that not infrequently the margin appeared to have been injured, often having a small crack or split through which the organism may have entered. There were, however, not a few instances in which no evidence of an abrasion or puncture could be detected on the leaf when carefully examined with a hand lens.

FIRE BLIGHT IN THE SAPWOOD

Another interesting condition has been observed in connection with fire blight in the Yakima Valley, on the Comice pears and less frequently on Winter Nelis and Bartlett pears. On several occasions, and from widely different sources, the writer's attention has been called to a condition occurring on limbs and twigs infected with fire blight where the sapwood and sometimes the pith showed a decided reddish color similar to the red streak that is characteristic of fire blight. A photograph of a number of branches of the Comice pear showing the coloration in the sapwood is reproduced

in plate VII, figure 2. Many of these branches were three-quarters of an inch in diameter and apparently not any more severely affected than hundreds of others that did not show this peculiarity. In some cases this color was manifest a foot or eighteen inches beyond where the bark showed discoloration. The grower, in whose orchard this condition was most prevalent, maintained that in order to be effective the cuttings for fire blight must be made beyond this red streak. He attributed practically all his reinfections at the wounds to a failure to get beyond this condition. In consequence of this he adopted the plan of examining each cut, and if the streak appeared, to cut farther back. He considered that only by so doing was he safe from further infection.

An effort was made to determine whether this peculiar condition was caused by the blight organism or merely associated with it. Many examinations of twigs and branches were made, the red streak always being found on limbs that were or had been blighted and never on perfectly sound, normal branches. From this fact it was concluded that this condition was due directly or indirectly to fire blight. Gross cultures and also tube cultures were made of the red sapwood with varying results. In only a few instances did gross cultures on pears, such as has already been referred to, produce the characteristic fire blight reaction. Better results were obtained when the twigs were split, a small portion of the colored sapwood detached with a sterile knife and transferred to tubes of glycerine or bouillon agar. When bacteria appeared in quantity, a portion of agar with as many of the bacteria as possible was gouged out and transferred to the sterile pears. Under such conditions some undoubted blight organisms were obtained, but not as readily or abundantly as from similar cultures taken from the bark. In the bark, the organisms are regularly found beyond the characteristic red streak, while in the sapwood no organisms could be obtained towards the outer limits of the colored area.

It would appear from these observations and experiments that under certain conditions of terminal or fruit-spur infections, the bacteria may invade not only the bark but the young sapwood and even the pith. Miss Bachmann[4] has already shown that these bacteria may readily enter the xylem tubes which, "in some places in a shoot, are so packed with the organisms that the transmission of sap in such a region seems quite impossible." When the organisms attack the young shoots, destroying the tissues, the bacteria have practically free access to all the cells. Among others they succeed in entering the xylem tubes and even the pith. As the cells at the end of a recently infected twig gradually become killed,

[4] Bachmann, Freda M The migration of Bacillus amylovorus in the host tissue. Phytopath. **3**: 3-14 1913.

the so-called "negative pressure" may be set up, aiding the organisms to migrate backward from the tip in the tracheae. The color, or that which produces it, is carried beyond the organisms.

It has been observed in connection with some other experiments that, when tips of branches were cut under water and immediately placed in a bottle containing a certain solution, a four-ounce bottle was emptied within a few hours. It seemed desirable to know through what tissue this liquid passed. For this reason bottles of eosin were used instead of the colorless solution and it was found that to a certain distance the coloring matter was equally distributed through the sapwood, wood and pith but that it travelled farther in the sapwood than in the pith, while there was practically no trace of it in the bast tissues of the bark. It would appear from this that liquids will pass readily in the sapwood from the tip of a branch backward, at least under conditions found in the Yakima Valley where the weather is extremely dry and warm during the summer.[5]

The red streak was often found six or eight feet from the tip of the branch, but no organisms were obtained in this region. Nearer the tip, however, frequently extending two feet from it, the bacteria were plentiful. Sometimes in older branches of a preceding year's growth, that were over an inch in diameter, this streak could be detected readily. In such cases, however, as is shown in figure 3, a and b, plate VIII, the infection could be traced to a small lateral branch, the organisms gaining entrance to the xylem tubes near the tip and then working their way back into the larger limb, the coloration extending beyond the region of the organisms. This condition was frequently found in fruit-spurs running back not only in the sapwood but also in the pith. Sometimes the red pith would extend six inches or a foot from the tip but in no case, either with the red pith or red sapwood, could living organisms be obtained towards the limit of coloration.

FIRE BLIGHT IN THE YAKIMINE

Fire blight on the Yakimine, a cross between a prune and a peach, has been found frequently. An example of terminal infection of a Yakimine appears in plate VIII, figure 4.

FRUIT INFECTION

There was observed during this season an abnormal amount of fruit infection on both apples and pears. In many instances these were out of

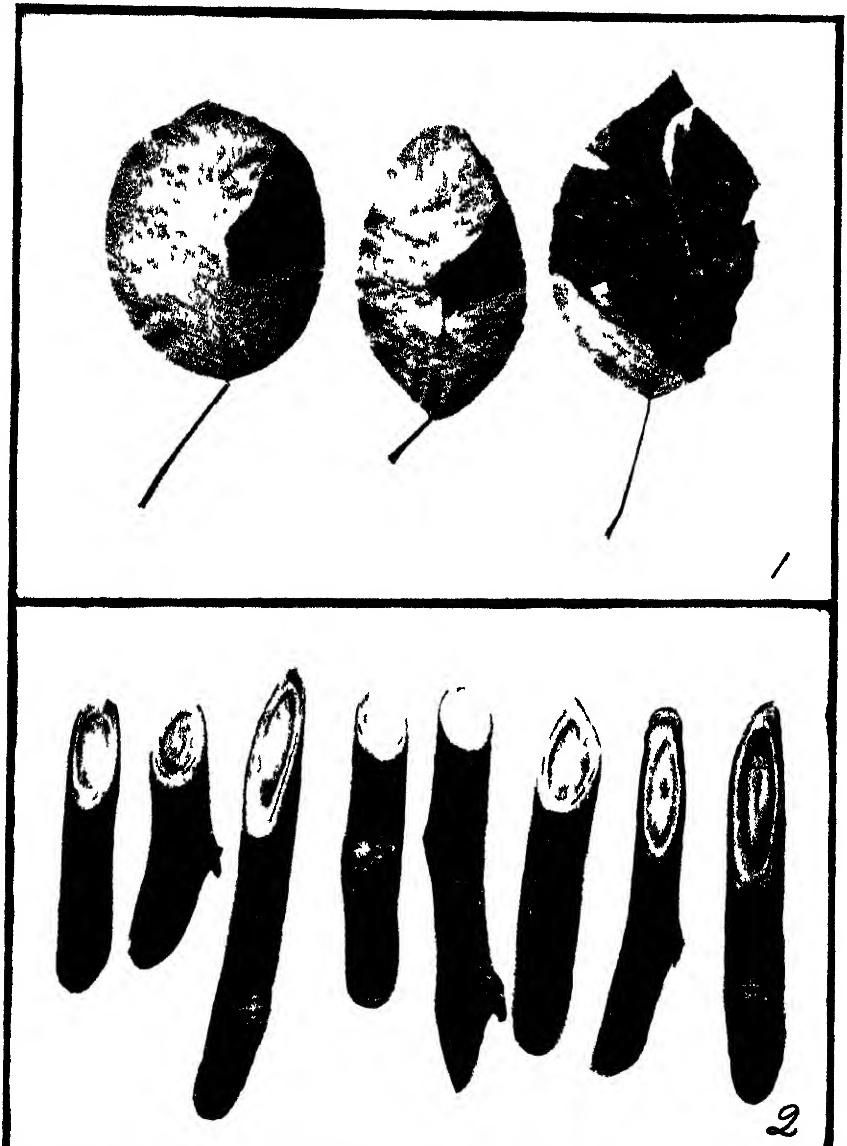
[5] Similar experiments with eosin conducted at Seattle, Washington, during November and December, when it was raining nearly every day, gave practically the same results.

all proportion to the number on the twigs and branches of the trees. An excessive number of insect punctures on the fruit may have been the cause but no definite evidence could be obtained on this point. In some cases this abnormal condition was traced directly to the manner of thinning the fruit. It was found that in a certain orchard a large percentage of the fruit infections occurred at the fresh wounds made by pulling off the apples when thinning. In the same orchard practically all stages of infection were observed. In some cases it could be detected only a few centimeters from the wound; in others it extended down into the fruit spurs, while in still others it had extended not only into the fruit spur but out into the fruit, as is shown in figure 5, plate VIII. At the point (*a*) in this figure are beads of exudate.

On August 11, 1914, a severe hailstorm swept over the Fairview district, a short distance from North Yakima, almost defoliating many of the fruit trees. About ten days after the hailstorm numerous new fire blight infections were observed on pear trees in this vicinity and a week later had reached the proportions of a serious epidemic, threatening the whole district. On examination it was found that the hail had made deep wounds in the bark of the young twigs, the organisms evidently gaining entrance at these injuries. More conspicuous than twig infections, were those on the fruit. On many trees two-thirds of the pears were injured by the hail and of these fully half became infected with fire blight. On large trees ten or fifteen years old where the growth during the summer had been slow but substantial, few twig infections occurred but 50 to 60 per cent of the injured fruit soon began to show evidence of disease. In many instances an abundance of infected fruit was found on trees that had no evidence of being previously infected. The rapid spread of the disease to uninfected trees was probably due to various kinds of insects, especially ants attracted to the fruit by the exuding juice. A greater number of infections occurred on the fruit as it was more susceptible to the disease than the twigs. To guard against a more serious epidemic the injured fruit was immediately picked and destroyed. With this precaution the disease was no more serious in this region the following spring than in other districts where there was no hail.

The writer is indebted to Mr. Henry Schmitz and Mr. C. E. York for taking the photographs.

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON



HOTSON FIRE BLIGHT

FIG. 1 Fire blight on the leaves of Bartlett pears

FIG. 2 A series of cuttings from branches of the Comice pear showing the coloration in the sapwood

HOTSON. FIRE BLIGHT

FIG. 3. Cross sections of a two-years-old branch of a Bartlett pear showing the presence of the red streak which had been introduced by infected lateral branch as shown in *a* and *b*. In *c* the bark has been removed.

FIG. 4. Fire blight on the Yakimine.

FIG. 5. Fruit infection as a result of thinning apples.

REVIEWS

Gribnye Parasity Vysshikh Rastenii Kharkovsk. i Smezhnykh Gubern. A. A. Potebnia. Kharkov Obl. Selskokh. Opyt. Sta., No. 1, str. 1–120, ris. 1–19. 1915. (Fungous Parasites of the Higher Plants in Kharkov and Adjacent Provinces. A. A. Potebnia. Kharkov Prov. Agr. Exp. Sta., No. 1, pp. 1–120, figs. 1 19. Kharkov, 1915.)

Upon the reorganization of the Kharkov Provincial Agricultural Experiment Station in 1913, with jurisdiction over practically all of four adjoining provinces, and the establishment of a well equipped department of plant pathology, A. A. Potebnia, pathologist in charge, made a thorough plant disease survey of this region. He now proposes a series of publications, based on his actual observations and studies as well as on the previous literature which, when completed, will cover every group of the fungous parasites and diseases with illustrations of the most important ones. The above book is the first number of this series and deals with the three lower classes of organisms, namely, Bacteria, Amoebae, and Phycomycetae. Attention is given to those forms which are actually found within the territory of the Kharkov Station, as well as to those the eventual discovery of which might be expected.

It is of interest to note that several important parasites, occurring either in Europe or in America or in both these countries, as yet have not been found in Russia or, at least, no typical outbreak has taken place to warrant a definite conclusion. They are as follows: *Bacillus phytophthorus, Bacillus amylovorus, Spongospora subterranea* and *Synchytrium* (*Chrysophlyctis*) *endobioticum*. On the other hand, three new plants are described which as yet have not been reported in this country. As they may prove to be of considerable pathological significance and as no Latin diagnosis accompanies their Russian description, mention of a few more important details regarding their characters will not be superfluous.

One is a bacterial organism, named *Bacillus petroselini* n. sp., and is accounted the cause of a leaf spot of *Petroselinum sativum*. The spots are small, 2 to 3 mm. in diameter, limited by the veins of the leaves, yellowish with a brown border. The parasite gains entrance through the stomata and disorganizes the tissues, forming cavities filled with the bacteria. In the resting state, in the host tissue, the bacillus is small, almost coccoid, 0.8 by 0.5 μ, while in the motile state the size is up to 5 by 1 μ. Occasionally, resting rods are found as large as 8 to 9 by 1.5 μ. It forms large

zoogloeae, reaching 100 μ or more in diameter. The colonies on beef agar and gelatin are white at first, then turn okra-yellow. The gelatin is not liquefied. A long period of drying does not kill this bacillus and typical pure cultures were obtained from dry, two-years-old, herbarium material. No mention is made of inoculation experiments. The bacterium is said to be of the same type as *Bacillus burgeri*[1] and *Phytobacter lycopersicum.* It is to be regretted that the description is not completely worked out according to the chart of the American Bacteriologists, nor is the group number given; therefore, it would be difficult to identify this organism in this country should a similar trouble be found here.

Two other plants belong to the group of Amoebina (Monadineae) and are named *Pollinopsis betae* nov. gen. et sp. and *Amoeba cucumeris* n. sp. The first form was found to be associated with a disease of beets caused by *Bacterium beticola* Erw. Sm. The author has no doubt that the same organism was observed by J. Brzezinski, of Cracow, and named by the latter *Myxomonas betae.* However, the life history of this amoeba was not correctly understood by Brzezinski and none of the six stages of development described by him actually exists. For this reason a new name is given. Potebnia succeeded in isolating *P. betae* and growing it in cultures. A study of its life history shows the presence of two stages, (a) amoeba and (b) cysts. The amoebae have an elongated shape, are from 15 to 25 μ (maximum 45 μ) in length, and move forward at one end, at which the ectoplasm sends awl-like pseudopodia in various directions. The middle and posterior portions of the body are filled with a granular, greenish endoplasm. The nucleus is found in the middle or nearer to the anterior end. The back portion contains a vacuole and during the motion of the amoeba is always accompanied by a dense cluster of bacteria, actively motile and apparently attracted by some secretion of the amoeba. As soon as the food is exhausted, the bacterial bundle disappears. The amoeba undergoes various changes in shape and appearance and finally turns into the resting stage or cyst, with a brown, double-walled, protective membrane at maturity. On germination the contents of the cysts emerge through an opening in the membrane and soon become young amoeba, without pseudopodia at first, but later on taking a typical appearance as described. The presence of the bacterium seems to be necessary for the growth of this organism. Whether a definite substratum, i.e., beet tissues, is also necessary for it is a question which is yet to be solved. The finding of this organism in connection with an apparently

[1] This name is given by A. A. Potebnia to the organism described by O. F. Burger in Florida and considered to be identical with one causing a similar trouble of cucumbers in Russia.

identical disease of beets in widely separated regions suggests that the association is not a casual one.

Amoëba cucumeris was isolated from sticky exudates which appear on cucumber fruits affected with *Bacillus burgeri*. Examination of herbarium specimens from Bubák and Kabát (Copenhagen), affected with a similar disease, revealed the presence of the cysts of the same organism. They are hyalin, oval, pear-shaped, or asymetrical, occasionally almost round, measuring 5 to 7 by 3 to 4 μ, surrounded by a thin membrane which is very difficult to stain when mature. The cyst germinates in broth or beef agar by bursting at one side and the contents flow out in the form of an amoeba. The latter are also hyalin, 5 to 20 μ in diameter, and begin to move immediately upon emerging. This organism is not thought to be pathogenic, but its constant association with certain bacteria, as is the case also with some other amoeboid organisms, raises an interesting question in regard to their rôle during the development of the disease and their relation to bacteria. There was no particular difficulty in obtaining cultures of *A. cucumeris* on ordinary beef agar, but its multiplication was observed only when bacteria were present. An interesting process of feeding upon these latter is described. Bacteria-free amoebae usually formed an aggregate plasmodium. The author made a series of experiments in order to determine the relation of this amoeba to various other bacteria, by inoculating with it pure cultures of eighteen different species of Bacillus, Sarcina and Vibrio. He found that all of them are fitted for the food of the amoeba. However, *B. burgeri*, a bacterium of the type *Semiclostridium commune*, *B. coli communis*, and *B. typhi abdominalis* were destroyed most rapidly and most completely.

In conclusion, two remarks may be added regarding the terminology accepted by Protebnia in his book. The transcription of the names of large groups with the commonly used suffix "mycetes" is the same as that introduced by Saccardo beginning with Volume XIV of "Sylloge," i.e., Schyzomycetæ, Myxomycetæ, Phycomycetæ, etc. (meaning *plantae*). In the specific names the suffix "cola," as a noun derived from the Latin word "colo," is preserved unchanged regardless of the generic designation; therefore, *Bacterium beticola*, etc. (the same as *agricola*). If the rules of etymology are to be observed, these two points seem to be well deserving of consideration.

MICHAEL SHAPOVALOV

Bitter pit investigation. The past history and present position of the bitter pit question. McAlpine, D. First progress report. 197 pp., 33 plates and frontispiece. 1911 12.

Bitter pit investigation. The cause of bitter pit: Its contributing factors together with an investigation of susceptibility and immunity in apple varieties. McAlpine, D. Second progress report. 224 pp., 60 plates and frontispiece. 1912–13.

Bitter pit investigation. The control of bitter pit in the growing fruit. McAlpine, D. Third progress report. 176 pp., 37 plates and frontispiece. 1913–14.

Bitter pit investigation. The experimental results in their relation to bitter pit and a general summary of the investigation. McAlpine, D. Fourth report. 178 pp., 40 plates and frontispiece. 1914–15.

The last of a series of four large volumes on the subject of bitter pit of pome fruits has recently been published by McAlpine. The series of publications furnishes by far the most elaborate treatment ever given this subject and is probably the most voluminous report that has ever been made upon any single plant disease. It gives a full review of the literature and is illustrated by nearly four hundred figures.

The description given of the disease in its typical form is similar to that found in earlier publications on the subject. The writer, however, includes what is known in the western United States as hollow apple as a form of bitter pit, calling it confluent pit or crinkle. Some of the figures would indicate that spots which in the United States have been called stigmonose, and others which have been attributed to extreme drought or to peculiar soil conditions, are also included under the term bitter pit. It is stated that the disease usually develops in storage or as the fruit is approaching maturity but often occurs when the apple is one-half or three-quarters grown. The wide latitude the author gives in time of development is probably made necessary by the great inclusiveness given the term.

As to the cause of the disease, McAlpine rejects White's theory that bitter pit is due to local poisoning by spray material, and supports his opinion by experiments showing that the disease is as common on unsprayed as on sprayed trees and by chemical analyses showing that arsenic is not present in bitter pit tissue. He also rejects Ewart's theory that bitter pit may be produced by poisons absorbed by the roots, pointing out that Ewart has not considered the effect that these poisons might have on the roots themselves, and giving experimental data to show that bitter pit did not develop on the fruit of detached branches when their stems were allowed to stand for more than two weeks in solutions of copper sulphate or mercuric chloride, nor did trees that were watered

with a copper sulphate solution show any increase in the disease. The latter experiment, however, was considered rather inconclusive. In his first report the theory of Pole Evans that the diseased condition is produced by the bursting of the cells from too great internal pressure is rejected because it seemed to offer no explanation for the fact that the disease develops only in certain parts of the apple and because a microscopical examination showed that the cell walls of the affected tissue were in reality not ruptured. In the fourth report he suggests the possibility that the rupture of the cells from turgor may in some cases be the cause of the disease.

McAlpine accepts the theory presented by Wortmann and later supported by Zschokke, that the death of the cells in the case of bitter pit is due to the concentration of the acid of the sap resulting from loss of water, but he does not accept the main proofs they offer in support of the theory. The author's whole discussion of the cause and nature of the disease, however, may be considered an elaboration of the above theory. He thinks the theory accounts for the development of the disease, both in storage and on the trees, and in the latter case for its development in wet as well as in dry weather. During dry weather or when dry and wet weather rapidly alternate, the lack of water in the cells is brought about by transpiration exceeding the water supply. When there is continued wet weather or when the fruit is unduly forced from any cause, the death of the cells by drouth results from the fact that the pulp tissue grows so rapidly that there is not time for the formation of the new vascular tips that are needed to supply them with water. In the first volume the writer seems to ignore the ability of water to pass readily from one pulp cell to another, but later he states that this transfer is not rapid enough to supply the needs of the pulp cells in the case of such rapid growth. No proof is given that new terminal vascular tissue is formed in the nearly mature apple when it is making a less rapid growth. In the first volume the writer lays great stress upon the smaller vascular bundles near the surface of the apple, and states that the failure of other workers to find a solution to the problem lies in the fact that they never suspected the existence of these. These vasculars were described and partially figured by Grew as early as 1682 and their existence is a matter of common knowledge among botanists. The excellent photographs and descriptions of the vascular tissue of the apple in the volumes under consideration do not need such extreme assumptions to establish their worth.

From weather records and orchard observations the author comes to the conclusion that the disease may be bad in either wet or dry seasons and that a sudden change in the water supply furnishes the most favorable condition for its development. Irrigation experiments were performed

without very definite results, but there was slightly less pit on the trees receiving two irrigations than on those receiving one.

Extensive fertilizer experiments were made in various sections of Australia. The results varied with the soil and the weather and no general conclusions could be drawn. The results as a whole, however, showed an increase rather than a decrease in the disease from the use of fertilizers. Green manuring seemed to decrease the disease.

Of all orchard operations pruning was found to have the most direct effect upon the development of bitter pit, excessively pruned trees developing the greatest amount of the disease. Cincturing of trees or limbs was found to reduce the disease.

A very full discussion is given of the relative susceptibility of varieties, and explanations are offered for the differences found. Chemical analyses of normal and diseased fruit are reported.

Storage experiments showed that uniform low temperatures (30° 32°F.) retarded the development of bitter pit, while high and fluctuating temperatures (35°–60°F.) were favorable to its development.

The illustrations are excellent and in addition to the full report on bitter pit many interesting horticultural notes are given.

CHARLES BROOKS

PHYTOPATHOLOGICAL NOTES

Pleosphaerulina on alfalfa. The note by Mr. Leo E. Melchers, of Manhattan, Kansas, on "A new alfalfa leaf spot in America" in Science n. s. 42, no. 1085: 536, October 15, 1915, leads the writer to contribute this note, which adds certain facts regarding the distribution, cultural habits, and taxonomy of this fungus.

While investigating certain diseases of alfalfa leaves at Madison, Wisconsin, the writer in July, 1914, first isolated Pleosphaerulina from alfalfa leaves. The cultures were obtained from small spots, which before that time were not distinguished from early stages of the spot caused by the fungus *Pseudopeziza Medicaginis.* The two spots were frequently intermixed on the same leaflets in varying proportions. The distinction is not a difficult one when the small, delimited, depressed, brown or gray center of the Pleosphaerulina spot is once noted. These small, uniform spots, 1 to 2 mm. in diameter, have often been found scattered abundantly over the leaves of young, vigorous plants when the large, dead areas bearing perithecia were difficult to find.

On March 3, 1915, alfalfa plants were received from Mr. H. B. Tisdale, Auburn, Alabama, bearing many of these minute spots all over the foliage. When the younger leaves were decolorized in acetic acid and alcohol and examined under the microscope, a large, dictyosporous spore was found in the center of almost every spot, and usually the penetrating germ tube could be observed. Further careful search of the material revealed a few perithecia on the stipules, producing spores similar to those found on the spots. Cultures from single spores from these perithecia and from platings from the small spots on the leaf were indistinguishable from each other, and likewise indistinguishable from the cultures from similar spots previously found on alfalfa at Madison, Wisconsin. Similar cultures have been obtained from ascospores from larger spots on leaves and from blackened stems of alfalfa plants sent by Mr. Eubanks Carsner from Norfolk, Virginia.

In addition to collections already mentioned, viz., from Alabama, Virginia, and Wisconsin, the fungus has been collected during the past summer by the writer from points in Iowa, Minnesota, and South Dakota, and by Mr. R. D. Rands in Indiana.

In pure culture, black, perithecial structures appear abundantly, but under ordinary conditions these fail to produce spores. After many experiments, it was found that in young cultures on oatmeal agar and

potato agar kept constantly at the temperatures 7.5°, 5°, and 1.5°C., spores matured somewhat sparingly in from 14 days at the higher temperature to 90 days at the lower temperature. This led to the discovery that in similar cultures kept out of doors in a shaded place spores matured abundantly, especially in the spring and fall.

A number of inoculations of normal alfalfa plants in the greenhouse have been made with these ascospores, but with no certainly positive results. However, from the evidence of leaf penetration by germ tubes, referred to above, and the appearance of the disease in the field, there seems no doubt that the fungus is under certain conditions a parasite. Further work is needed to determine the special conditions under which infection occurs.

The identity of the fungus with previously described species was not clear from the published descriptions. Hence it was arranged by Mr. Melchers and the writer to submit their collections to Dr. C. L. Shear for comparison with available exsiccati. This he has kindly done, and the following quotation from his letter, published with his consent, gives his findings.

"No. 383, Briosi and Cavara, Fun. Par. Exs. This specimen shows perithecia, asci, and ascospores, agreeing in every respect with Pollacci's illustration in his original publication of *Pleosphaerulina briosiana*. The ascospores measured 25 to 28 by 12 μ and eight to ten asci were found in some perithecia. Pollacci's original description gives 20 to 25 by 6 to 8 μ for spore measurements. This I fear is an error[1] as none of the European specimens we have examined show spores of these widths. The ratio between length and width in his measurements does not agree with that shown in his original figures of the spores. The ratio in his drawings is approximately that given by our measurements.

Another European specimen, 1290, D. Saccardo, Myc. Ital., shows asci and spores of the same size and appearance.

The specimen sent Mr. Melchers by Bubák from Moravia also agrees with the others just mentioned. There are occasionally found young or imperfectly developed spores 18 to 20 μ long. In the American specimens from Kansas and those from Wisconsin and Iowa we find quite constant and uniform measurements of ascospores ranging from 25 to 30 by 12 to 14 μ. In number of asci, in shape of asci, and in size and character of perithecia we find little or no difference between the American and European specimens. We are therefore of the opinion that they all belong to the same species, *Pleosphaerulina briosiana* Poll."

FRED REUEL JONES

[1] Bubák likewise suspected that this measurement was given incorrectly, and upon obtaining original material from Pollacci, found this to be the case. Wiener Landw. Zeit. **59**: 909. November 20, 1909.

Dissemination of bur clover leaf spot. Bur clover (*Medicago arabica* and *Medicago hispida*) is more or less severely attacked in portions of Alabama by one of the leaf spot fungi, *Cercospora Medicaginis* E. & E. The disease is most destructive in April and May, at the time of maturity of its host. Since bur clover is a winter annual and the seed may remain dormant from May until the following autumn, interest is attached to the annual reappearance of the disease.

It was found by an examination of the centrifuged washings of bur clover seed, from collections made during July, August and September, that Cercospora conidia were commonly present. It is probable that the introduction of leaf spot to new localities is due to the presence of viable conidia on the surface of the burs. That these conidia remain viable is indicated by the fact that the cotyledons of seedling bur clover plants have been observed under field conditions to be affected with Cercospora. The disease then spreads to the true leaves, as soon as they are formed, and the leaf spot organism lives over winter in leaf spots on the sheltered leaves.

Preliminary tests indicate the possibility of controlling its further spread by seed treatment. Immersion for one minute in boiling water, a treatment designed to hasten germination of the bur clover seed, seems at the same time to destroy the viability of the conidia. Plants grown from seed treated with formaldehyde were also free from leaf spot.

FREDERICK A. WOLF

Neocosmospora vasinfecta Erw. Sm. on potato and adzuki bean. During the season of 1915, the perithecial stage of *Neocosmospora vasinfecta* has been found at Auburn, Alabama, on two species of plants not previously recorded, Irish potato and adzuki bean (*Phaseolus angularis*). The specimens on Irish potato tubers were collected by Prof. A. B. Massey. The perithecia had formed on the surface of the tubers, being especially abundant around the "eyes," with no evidence of decay. Decomposing organic materials in the soil appear to have served as the source of food for the vegetative growth of the fungus.

The perithecia appeared upon the dead stems of adzuki beans. These beans had been grown on wilt-infested soil and beyond doubt had succumbed to the attacks of Fusarium.

The fungus on both of these species agrees morphologically with *Neocosmospora vasinfecta* from peanuts, with which it has been compared and is therefore believed to be identical with it.

FREDERICK A. WOLF

Sclerotium rolfsii Sacc. on Citrus. *Sclerotium rolfsii* is known to occur ubiquitously throughout the Southern States upon a wide range of hosts. A recent paper (Earle, F. S., and Rogers, J. M., "Citrus Pests and Diseases at San Pedro in 1915," 1st Ann. Rpt. San Pedro Citrus Pathological Laboratory, San Pedro, Isle of Pines, W. I., p. 3–41, figs. 19, 1915) records for the first time that it is capable of producing a rot of Citrus fruits when they come in actual contact with the soil. During the past season this fungus caused the death of seedling grapefruits (*Citrus decumana*) in the greenhouse at Auburn, Alabama. The soil in which these seedlings were grown was infested with *Sclerotium rolfsii* from some inoculation tests conducted during 1914. Infections were first evident on the stems at points near or several inches above the ground level. The diseased cortex was brown, in sharp contrast with the normal green tissues. Within a week the little trees had been girdled and were dead and dry. Soon afterward sclerotia formed on these dead seedlings. The organism was isolated in pure culture from these seedlings and to all appearances was found to be identical with a culture of *Sclerotium rolfsii* obtained from diseased peanuts.

FREDERICK A. WOLF

Spread of the chestnut blight in Pennsylvania. Mr. I. C. Williams, Deputy Commissioner of Forestry of Pennsylvania, has recently issued the following statement regarding the present status of the chestnut blight in Pennsylvania. In view of recent statements circulated in the newspapers, apparently by nursery interests, to the effect that the chestnut blight is coming to a standstill, this statement of Mr. Williams' is of considerable interest to plant pathologists.

HAVEN METCALF

Since the Chestnut Blight Commission has passed out of existence, the Department of Forestry has been keeping an eye on the blight situation in Pennsylvania. Recently the statement has been made frequently that the blight has run its course and is gradually dying out in the State. To discover the truth of this statement, the Department addressed a circular letter to fifty-four of its foresters, covering forty counties, asking if the blight was spreading, receding, or apparently stationary in their districts.

Replies have been received from fifty of the foresters. Twenty-eight report the blight spreading rapidly; eight report that it is apparently stationary; one reports it receding; and fourteen report no blight on or near their forests.

The infection reported farthest west is in northwestern Clearfield county; that farthest east in central Pike county; that farthest north in northwestern Tioga county; and that farthest south near the Maryland line in Franklin county.

Pinus resinosa, a new host for Peridermium acicolum. In June, 1915, while at Itasca Park, Clearwater County, Minnesota, the writer found

about one mile from the Minnesota Forest School headquarters, an open stand of young red pine (*Pinus resinosa* Ait.) from two to eight feet in height, of which practically all the trees examined, numbering seventy-five, were more or less affected by a needle rust. Specimens (F. P.[1] 18064 and F. P. 18065) were sent to Washington, D. C., and the fungus identified by Dr. George G. Hedgcock, of the Office of Forest Pathology, as *Peridermium acicolum* Underw. & Earle. The trees seen were in a clearing not far from the woods. Some of the small trees, under three feet in height, were nearly covered with the rust, which had the effect of stunting the trees. On the other hand, no noticeable injurious effect was seen on trees six to eight feet in height. On the larger trees the rust was much less abundant than on the smaller trees.

It has since been learned from Prof. J. H. Allison, of the University of Minnesota, present at the time of the first collection, that the rust on the red pines extended into the woods from the young pines in the clearing, a distance of from forty to sixty rods. None of the trees in the woods were as badly affected as those in the opening, nor was there such a large percentage of them affected.

G. G. Hedgcock also collected *Peridermium acicolum* on a single seedling of *Pinus resinosa* (F. P. 17799) in a nursery near Caledonia, Pennsylvania, in June 1915.

As far as known to the writer this is the first time that a rust has been reported on *Pinus resinosa*.

ROY G. PIERCE

The Rio Grande lettuce disease. A preliminary survey of the trucking section of southeastern Texas has shown the presence of a disease of lettuce not hitherto described. This disease occurred to a slight extent last year and it has been particularly destructive this year in the large acreage of this crop in the Rio Grande Valley. Since no similar disease of lettuce is known to the writer it was considered advisable to record the symptoms as observed. To distinguish this disease from other troubles of lettuce the name Rio Grande disease is suggested.

The disease is manifested by the general symptoms of an impoverished and gradually dying plant. These gross symptoms may be grouped as follows: (1) reddening of the older leaves and blanching of the younger, central leaves, (2) restricted development of newly forming leaves, accompanied by small, dark-colored, blister spots along the border, (3) development of numerous lateral adventitious shoots, and (4) dry and dead small roots. The general appearance of the disease differs with the age of the affected plants, the symptoms being present in varying degrees.

[1] F. P. = Forest Pathology Investigations' number.

FIG 1 Lettuce plant affected with the Rio Grande disease, showing the development of numerous adventitious shoots, also heart leaves from plant affected with the disease, showing the characteristic blister spots along the margins.

The younger plants cease to grow, gradually turn red, and die. Half-grown plants, if affected, are readily detected at some distance by the blanched appearance of the center. Frequently also the outer leaves are reddened. If the central leaves are pulled apart, exposing the growing small leaves, it will be seen that the latter present the spotted appearance along the border as illustrated in the figure. These spots are more or less blister-like and contain, under the epidermis, a brown, pulpy mass of disorganized tissue. A more advanced stage of the disease is accompanied by a further disorganization and drying down of the tissues of the growing parts.

An additional symptom commonly observed on plants of the size to form heads is manifested by the development of a large number of adventitious shoots. A closer observation showed that the small roots of all affected plants which were examined were dead, the cortex readily slipping from such roots. No parasitic insects or fungi were found constantly associated with this disease. However, microscopic observations were limited to those which could be made with field equipment.

Since all of the observed symptoms indicated a root trouble a few preliminary chemical analyses[1] were made of the irrigation water used and of the soil about affected plants. The results of these analyses, considered in addition to other available analyses[2] of Rio Grande River water, indicate that the alkali problem is sufficient in this locality to offer a partial explanation of this disease of lettuce.

C. W. CARPENTER

Rhizoctonia and Sclerotium rolfsii on sweet potatoes. Rhizoctonia has been commonly found causing considerable damage to young plants in the hotbeds in Florida and Alabama and to a less extent in New Jersey. In the South the fungus causes a decay of the underground parts of the stem. The leaves turn yellow, the plant remains dwarfed, and finally dies. In New Jersey the same fungus is suspected of causing dark, sunken cankers on the stem of the plant, near the soil line. These cankers are at first small, but spread up and down and around the stem, and may eventually bring about the death of the plant. If, however, the disease is not too far advanced, affected plants may be set in the field without risk. The Rhizoctonia disease in the South was found to be more prevalent in beds that had been too frequently watered.

Sclerotium rolfsii has been found only in the South, and most de-

[1] The writer is indebted for these analyses to Mr. F. M. Scales, of the Office of Soil Bacteriology Investigations, U. S. Department of Agriculture.

[2] Clark, F. W. The data of geochemistry. U. S. Geological Survey Bul. 330: 69. 1908.

structive in Florida and Texas. This fungus spreads from the point of infection in a circular-like manner, destroying nearly all the plants with which it comes in contact over areas of a foot to several feet in diameter and sometimes over nearly the whole hotbed. It is most destructive during cloudy, wet weather and when the mat of leaves prevents the surface of the soil from drying out. Under such conditions a white mass of hyphae spreads over the soil and lower part of the stems and lower leaves. Later numerous sclerotial bodies of the fungus are developed.

L. L. HARTER

Reproduction of autochrome plates. The colored plate illustrating the article by Dr. V. B. Stewart (Phytopath. **6**: plate II) is a reproduction from a Lumiére autochrome plate and was secured through the courtesy of Dean B. T. Galloway of the Cornell University Agricultural Experiment Station. The original plate seemed to show too much yellow but the leaf was young and perhaps was more yellow than a fully developed leaf. The reproduction is very faithful and leaves little to be desired. In fact the brown shades seem to be better in the reproduction than in the original.

The four engravings from which the reproduction was printed were made by the Matthews-Northrup Works, Buffalo, New York. Mr. George E. Matthews, President of the company, has kindly furnished the following statement of the method employed:

The autochrome is placed in a shadow box with a strong reflected light behind it. The camera is focussed sharply and the intervening space completely darkened thus centering the light on the autochrome.

Four halftone negatives are then made filtering the various colors, one each to print yellow, red, blue and black. The angle of the screen is turned between each exposure as may be seen readily by examining the print with a hand lens. This prevents a "pattern" or smudgy appearance. The halftone screen negatives are then printed on a prepared copper plate just as one would print on photographic paper from a negative.

After the halftone negatives have been printed on copper, the plates are ready for etching. The finishing of the plates depends upon the skill of the re-etcher, who has to do the work that the camera cannot do. A camera has not yet been made, which when used with filters, will get absolute separation, so when the plates are first etched, they are usually not a very close reproduction of the object, and re-etching is necessary until all the tones and values of the original subjects are reproduced just as they are in the original.

In order to obtain the best results, it is important to have as nearly a perfect autochrome as possible.

Reproducing colored work from autochromes is more difficult than reproduction from a painting or actual object, as one has to contend with light reflection, which is very likely to change the color of the object from one moment to the next.

DONALD REDDICK

REPORT OF THE RIVERSIDE MEETING OF THE PACIFIC DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

A meeting of the Pacific Division was held at Riverside, California, in the rooms of the Plant Breeding Division of the Citrus Experiment Station, December 29, 1915.

Dr. J. T. Barrett, Vice-President, opened the meeting and expressed regret at the loss to the Division of its President through the removal of Professor Jackson to fields of labor outside the Pacific Slope district.

The Secretary explained that affiliation with the parent Society lacked only the approval by that Society of its Committee's action, the conditions having been approved already by this Society. Affiliation is also pending with the American Association for the Advancement of Science, Pacific Division. It was moved and carried that the matter of the next meeting be left to the Executive Committee to decide. The opinion was expressed by the members that two independent meetings per year is more than is needed to present the work of the members and caused considerable effort in the way of long journeys.

Dr. H. J. Webber suggested the propriety of this Society taking some action regarding the citrus canker disease, calling attention to the great importance of the citrus industry in the district covered by this Society, to the seriousness of the disease where it occurs, to the absence of any evidence that it would be less serious if introduced in groves of the Pacific Slope, and the great probability that it will be introduced into California if not suppressed in the eastern United States, and to the respect which the opinion of this Society should command from those responsible for deciding on the support to be given the project for eradicating the disease. On motion of Dr. H. S. Reed the Society resolved itself into a Committee to draw up appropriate resolutions in the matter to be addressed to the Committees of Congress. After due deliberation the Committee arose and the Society met in executive session to consider the report. On motion of Professor Reed, seconded by Professor T. F. Hunt, the following resolution was unanimously adopted:

"The American Phytopathological Society, Pacific Division, in regular session at Riverside, California, after discussion of the subject of Citrus Canker disease, has adopted the following resolution:

Whereas, since the disease was discovered in this country it has been found that it very quickly and easily spreads from one section to another, and that the injury from the disease has proven to be very disastrous to the industry in sections where it occurs; and because we believe it can be controlled;

Resolved, that this Society regards the Citrus canker disease a serious menace to the citrus industry of the United States, and

Resolved, that we urgently request your honorable body to give your moral and financial support to the best and most immediate measures for stamping out this disease where it now occurs, and to take whatever measures seem necessary to prevent further spread of the malady."

The Secretary was instructed to send copies of the resolution to members of the Agricultural Committees of Congress, to members of this Society and such other persons as might be interested.

The Secretary was instructed to send a telegram to Mr. Asbury F. Lever. The following telegram prepared and approved by the Society, was sent:

"HON. ASBURY F. LEVER,
Chairman, Agricultural Committee,
House of Representatives,
Washington, D. C.

Resolved that this Society in session regards the citrus canker disease as a serious menace to the citrus industry of the United States and

Resolved that we urgently request your honorable body to give your moral and financial support to its eradication.

(Signed) AMERICAN PHYTOPATHOLOGICAL SOCIETY,
Pacific Division,
WM. T. HORNE Secy."

The following papers were presented:

Notes on Oleander bacteriosis. C. O. SMITH.

Oleander bacteriosis is occasionally found in California on nursery stock and has been before reported and more or less carefully described from Italy and California.

The organism causes galls on the stem, leaves and inflorescence, which closely resemble the olive knot, *Bacterium savastanoi*, and the aerial galls produced artificially by *Bacterium tumefaciens*.

From the study thus far made, certain differences have been determined between the oleander organism and the other two gall-producing organisms. The oleander organism is able to cause knots by artificial inoculations on the olive and oleander, but gave negative results on the following plants that are susceptible to *Bacterium tumefaciens*, as shown by parallel artificial inoculations: Wickson plum (*Prunus*), *P. persica*, *P. amygdalus*, *P. cerasifera* and *Shinus molle*. The olive knot organism gave negative results on oleander. The olive was much more resistant to *Bacterium tumefaciens* than to the oleander organism, and the galls that developed were not one-tenth the size.

A new leaf-spot disease of cherries. BERT A. RUDOLPH

A cherry leaf-spot disease occurs on leaves of sweet cherry at a number of points in California and Oregon. The spot is rather large, brown, usually definitely bounded. It appears to originate, in many but not all cases, at an insect mine. An insect of the group Chalcididae has frequently been found in these mines but no other. No fungous spores or fruiting bodies were found on the spots occurring in nature, but tissue plantings on sterile media repeatedly yielded a fungus of the genus Alternaria. Single-spore cultures repeatedly gave the typical spot when inoculated into healthy leaves and the fungus was repeatedly and regularly reisolated from the artificial spots. Comparison with *Alternaria citri* Pierce and a species of Alternaria on watermelon leaf-spots in cultures showed the three fungi to be very similar but distinguishable by certain reactions.

Non-parasitic stem lesions on seedlings. CARL HARTLEY

Attention is called to a disease affecting the bases of the stems, and resulting in death of considerable numbers, of very young seedlings of conifers and various herbaceous plants. For this the name white spot is proposed. Though in many ways resembling parasitic damping off, and commonly confused with it, evidence is presented indicating that the trouble is caused by high temperature at the soil surface,

possibly combined with the effects of light. Loss from white spot can be decreased by partial shade and apparently by frequent watering. White spot lesions are distinguished from damping off infections by their light color, definite boundaries, and limitation to the part of the stem above the soil surface.

A basal girdling of two- to three-years-old stems has been attributed by Munch to the same cause as white spot. The correctness of Münch's view is questionable, for in the United States the disease of the older plants is almost entirely absent from the nursery in which the most white spot has been observed, and causes serious loss at a nursery where white spot is less common.

Observations on sour sap disease of apricots. EDITH H. PHILLIPS

Apricot trees affected with so-called sour sap or black heart show distress first in the outer branches, which begin to die back and in the wood of which are found brown streaks. Frequently one side of a tree goes in this way and occasionally a whole tree dies outright. Excision well below the darkened wood does not stop the advance o the disease. This trouble appears during summer and fall and is said to be particularly abundant in a wet year following one or two dry years.

Cultures of soil protozoa were made with roots with adhering soil, associated with diseased trees in one of the badly affected orchards, and with soil from the crowns of apparently healthy trees in the same orchard. Four cultures from material associated with diseased trees and two cultures from soil at the crowns of two apparently healthy trees were made. The protozoan faunas of the former cultures were found to be more diverse and abundant than those of the latter.

Factors influencing the distribution of certain Citrus diseases. H. S. FAWCETT

No abstract.

Red leaf-spot of Hippeastrum. PAUL I. DOUGHERTY

Conspicuous red spots, usually rather small in size, occur on the cultivated Hippeastrums or spring-flowering Amaryllis, causing blemishing and occasional deforming of leaves, scapes and flowers. Importance of the disease arises from the high value of individual plants and the desirability of producing them in entirely perfect condition. Hand sections of spotted tissue placed in drop cultures gave rise to an abundant mycelium. Homogeneous growth from this planted in sterile media grew vigorously, and on artificial inoculation into wounds produced the typical spots. The same fungus was reisolated from the artificially produced spots and infection again produced on healthy leaves. A Phyllosticta type of fruiting body with spores was developed in certain media and the typical fungus grown from single spores. Inoculations from the single spore cultures were also successful.

Phomopsis Mali on young apple and pear trees in California. ELIZABETH H. SMITH

Attention is called to a disease of young apple and pear trees found in California which very nearly resembles that reported in 1912 by J. W. Roberts in Virginia. The disease is caused by a fungus, named by Roberts *Phomopsis Mali*, which forms extensive cankers on the limbs, the bark affected being finally covered with the spore coils emitted from protruding pycnidia.

The trouble has been found only on one- to three-years-old trees, and thus far is of no economic importance in California.

Notes on control of walnut blight by spraying. W. S. BALLARD

No abstract.

A Gloeosporium disease of the almond probably new to America. HELEN L. CZARNECKI

In March, 1915, specimens of diseased almonds from Napa County, California, were sent to the University of California for examination. Investigations were made by the writer and the disease was found to occur to a limited extent in several orchards in Napa and Alameda Counties.

The disease appears mainly on the young green fruits, producing large, brown- to orange-colored, sunken spots, and often causing the fruits to wither and finally drop. The leaves of the younger branches show numerous confluent shot-holes.

The causal fungus is a species of Gloeosporium, apparently the same as that found on the almond in Italy and named *Gloeosporium amygdalinum* by Dr. Ugo Brizil of the Royal Phytopathological Experiment Station at Rome.

No previous record of the occurrence of this fungus in America has been found.

Some new applications of Plant Pathology. H. S. REED

No abstract.

The winter state of Synchytrium decipiens. J. T. BARRETT

No abstract.

A new species of Pythiacystis. J. T. BARRETT

No abstract.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

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All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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PHYTOPATHOLOGY

VOLUME VI — NUMBER 4

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POTATO WILT AND TUBER ROT CAUSED BY FUSARIUM EUMARTII

ROYAL J. HASKELL

WITH THREE FIGURES IN THE TEXT

Many attempts have been made by different workers to connect various potato tuber rots, caused by species of Fusarium, with a pathological condition of the top of the potato plant. As a result of these efforts[1] only two species of Fusarium, *F. oxysporum* Schlecht. and *F. trichothecioides* Wr., have been found to produce wilt, and even in these cases the positive proof is meager or entirely lacking. It is the object of this paper to report the pathogenicity of a species of Fusarium on the vines, as well as on the tubers, of the potato plant and to furnish the evidence on which this conclusion is based.

During the winter of 1914 affected potatoes were received from Lodi, New York. Some of the diseased tubers showed a sunken, wrinkled, dry, stem-end-rot of varying diameter while others gave only a slight indication of rot around the point of attachment of the rhizome. When specimens of this latter type were cut across near the base, however, browning in the region of the ring of fibro-vascular bundles was evident. This discoloration extended to various depths in the tuber sometimes affecting the whole fibro-vascular ring but more often involving only separate portions of it. The cells in the vascular ring showed the greatest discoloration and degeneration but the parenchyma on either side of the more badly affected areas usually appeared brown, yellowish, or water-soaked. When potatoes with the dry, sunken, stem-end-rot were cut,

[1] Manns, T. F. The Fusarium blight and dry rot of the potato. Ohio Agr. Exp. Sta. Bul. 229: 299–336, pls. 1-15. 1911.

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it was found that the rot was not confined to the bundles but involved the entire basal end.

The isolation of the causal fungus was made as follows: The tubers were first disinfected in corrosive sublimate solution (1–1000) for ten minutes after which they were partly cut through with a flamed scalpel, and then broken open. Plantings of diseased tissue from affected bundles on the broken surface were made into poured plates of a potato-agar medium. From 60 per cent of the plantings there developed a species of Fusarium having a pale olive-buff color on the medium used.

FIG 1 Plant on the left inoculated with *Fusarium eumartii*, the one on the right is a check Photograph taken 77 days from time of planting and 44 days after inoculation The stem of the inoculated plant is rotted through below the ground

As this Fusarium appeared to be different from any before reported, a culture was sent to Dr. C. D. Sherbakoff at the Florida Experiment Station. An examination by him showed it to be unlike any of those listed in his Fusaria of Potatoes and later a comparison of this organism with *Fusarium eumartii*, recently described by Carpenter,[2] brought out the fact that the two were identical. The following brief description and results of the comparative study are kindly furnished by Dr. Sherbakoff:

"Conidia slightly curved only in the upper third of their length and nearly straight in the lower two-thirds, seldom attenuated toward the

[2] Carpenter, C W Some potato tuber-rots caused by species of Fusarium. Jour. Agr. Research 5: 183–209, pls A–B, 14–19. 1915.

lower end as is the case with *F. martii* Ap. & Wr.; occupying, in type, a position intermediate between *F. martii* Ap. & Wr. and *F. coeruleum* (Lib.) Sacc., more resembling the latter type; 5-septate conidia always

FIG. 2. Stems of plants having the appearance of the diseased plant in figure 1 but at a slightly later stage.

greatly predominating over conidia of other septations, sometimes reaching 100 per cent.".

There follows Dr. Sherbakoff's comparison of *Fusarium eumartii* strain No. 3551 received from Mr. Carpenter, and *Fusarium eumartii* strain P which was used in this work.

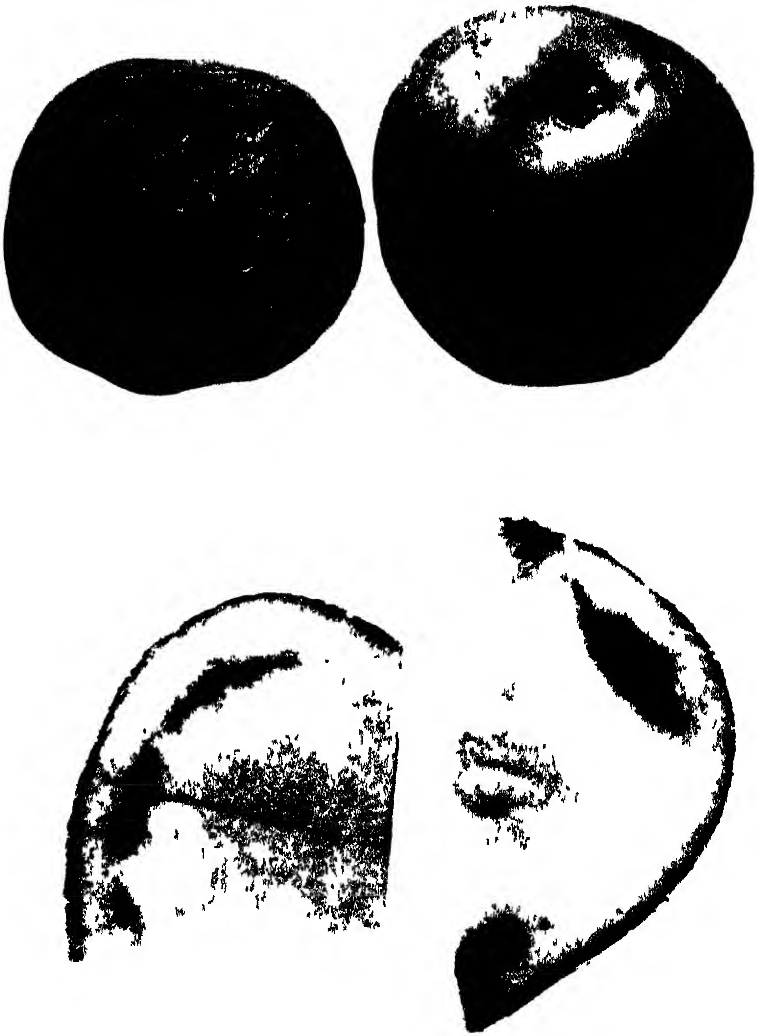

FIG. 3. Above, external appearance of affected potatoes when dug The stem-end lesion may be sunken and shriveled, or not, depending on conditions; below, internal appearance of tuber affected as is the one above on the right

Cultures on hard, oat-agar, thirty-six days old

1. Strain No. 3551.
   Conidia: 5-septate, up to 100%, 57 x 6 (50–63 x 5.8–6.3)μ
   3- and 4-septate, few
2. Strain *P*.
   Conidia: 5-septate, 95%, 58 x 6 (49–66 x 5.7–6.4)μ

Cultures on bean-pod plugs, twenty days old

1. Strain No. 3551.
   Conidia: 3- and 4-septate, exceptional
   5-septate, 90%, 55 x 6.1 (50–59 x 5.8–7)μ
   6-septate, 10%, 62 x 6.5 (57–69 x 6–7)μ
   7-septate, rare, 66 x 6.8μ
2. Strain *P*.
   Conidia: 3- and 4-septate, 10%
   5-septate, 89%, 57 x 6 (50–65 x 5.7–6.5)μ
   6-septate, less than 1 per cent, 6.3 x 6.1 (60–66 x 59–6.5)μ

Cultures on tomato-stem plugs

1. Strain No. 3551.
   Conidia: 3- and 4-septate, 2%
   5-septate, 96%, 56 x 6 (50–60 x 5.8–6.5)μ
   6-septate, 2%, 61.5 x 6.1 (58–66 x 6–6.5)μ
2. Strain *P*.
   Conidia: 5-septate, 82%, 57 x 6 (50–62 x 5.8–6.5)μ
   6-septate, 12%, 60 x 6.0 (55–70 x 5.8–6.5)μ
   7-septate, few, 65 x 6.2μ

After making sure that the cultures were pure,[3] inoculations of healthy plants were made.

On March 4, 1915 two plants in the greenhouse, four to six inches high, were inoculated by placing mycelium and spores in a small slit in the stem just below the level of the ground. Two similar neighboring plants were injured in the same way but no inoculum was introduced. At the end of twenty days both inoculated plants showed marked evidence of infection. On one the upper leaves were flaccid and the lower leaves were dead or dying, especially on the side where the inoculum was placed. The other plant showed a yellowing and wilt of the lower leaves at this time. Both stems below ground were found to be nearly rotted through.

Thirty-seven days after inoculation both plants were dead, broken and fallen over, with the fungus fruiting on the stem near the soil. The

[3] Cultures were obtained from the growth of a single spore by pouring dilution plates of clear agar and locating the spores with the low power of the microscope. The location was marked with ink and after germination bits of mycelium on agar were transferred to tubes.

two check plants remained healthy and continued to grow until they were taken up some time later.

Some of the small tubers which were formed on the diseased plants were found to be affected with an internal rot which in one case extended nearly through the potato. A single attempt to reisolate the Fusarium from these potatoes was not successful.

In order to try inoculations on a larger scale and under natural conditions, about fifty plants growing out-of-doors were inoculated during the summer of 1915. This was accomplished, for the most part, by injecting spores of the pathogene with a hypodermic needle into that part of the stem below ground. In this way only a very slight wound was made.

Out-of-doors, as in the greenhouse, the symptoms on the top began to appear about twenty days after inoculation. In the majority of cases this took the form of a leaf-burn, especially of the lower leaves, but in some instances the disease was manifested by a rolling or slight rosetting of the leaves. In the last stages the leaves wilted, followed soon after by death (fig. 1). At no time did these plants suffer from drought as there was an abundant amount of rain all summer. It is probable that the wilt symptom would be much more prominent in a dry season.

At the point of inoculation a dry rot developed which in time involved much of the stem below ground (fig. 2). Often the rot extended upward in the cortex, sometimes as far as the lower branches. From the cortical tissue the fungus gained entrance to the vascular elements within which it spread up and down the stem and into the tubers. Sometimes the inoculated stalks showed brown flecks in the pith high up in the plant, particularly at the nodes

When the hills were dug it was noticed that several of the potatoes from inoculated plants had a dry, stem-end-rot and vascular browning similar to that from which the Fusarium was originally isolated (fig. 3). None of the tubers from the numerous check plants, or from any other plants in the field, was thus affected. In addition to this the yield from the inoculated hills was much lower than that from the checks. Ten neighboring hills of the inoculated set yielded thirty-four tubers while ten adjoining check hills in the same row gave one hundred and seven potatoes of marketable size.

The Fusarium was reisolated from some of the tubers borne on the inoculated plants and was found to be identical with the original strain. To make positive of this, it was again inoculated into stems and found to cause the characteristic stem-rot and consequent death of the plant.

In order to test the true parasitic nature of this fungus on the potato top, sterilized soil in pots was inoculated with a flask culture of the organism and sprouted potatoes planted. Again, after about twenty days,

some of the plants began to wilt and die, and an investigation of the parts below ground showed that the main stem, some of the roots, and even some of the young potatoes had become affected directly from the soil.

On some of the tubers of inoculated plants the writer has noticed cases of outside injury which appears as a dry rot in spots on the surface, particularly at the "eyes," and it is believed that this may be one phase of the disease.

Potato tubers have been inoculated with this species of Fusarium and the results obtained correspond with those of Carpenter,[4] in establishing the fact that this fungus is a wound parasite. In table 1 are given the results obtained.

TABLE 1

Results of inoculation of potato tubers with Fusarium eumartii in 1915

ORGANISM	DATE OF INOCULATION	NUMBER OF TUBERS	AGE OF TUBERS	INCUBATION	PER CENT OF ROT
F. eumartii	March 28	1	old	26 days	100
	June 22	4	old	34 days	100
	October 13	4	new	30 days	100
	December 5	2	new	16 days	100

In all these cases there was a dry, sunken rot, produced about the point of inoculation, from two to five centimeters in diameter. The Fusarium was fruiting on the sunken surface, and the rot extended deep into the tuber in every case.

CONCLUSIONS

1. The organism is morphologically identical with *Fusarium eumartii* Carpenter.

2. As a result of pure culture inoculations, both in the greenhouse and out-of-doors, on sterilized and unsterilized soil, it is evident that *Fusarium eumartii* may produce both a wilt of the potato vine and a rot of the tuber.

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[4] Carpenter, C. W. Some potato tuber-rots caused by species of Fusarium. Jour. Agr. Research 5: 183–209, pls. A-B, 14–19. 1915.

THE MOSAIC DISEASE OF TOMATOES AND PETUNIAS

H. A. ALLARD

WITH TWO FIGURES IN THE TEXT

In 1908, Clinton,[1] working in Connecticut, first proved conclusively that the mosaic disease of tobacco is communicable to healthy tomato plants, and vice versa. This is perhaps the first definite evidence adduced to indicate that the infectious mosaic disease of tomatoes is identical with the well-known mosaic disease affecting the tobacco plant.

The writer's experiments also show that the mosaic disease of tobacco is readily communicable to the tomato plant and produces well-marked changes in the structure and appearance of the leaves. A more or less pronounced mottling of the leaves, characteristic of mosaic alone, is generally indicated. In some phases of the disease, the leaves are so completely dwarfed and misshapen as to bear no resemblance whatever to a normal leaf. The nature and intensity of the symptoms of mosaic depend, to a considerable degree, upon the variety of tomato affected. The larger leaved sorts show all phases of the disease in a most pronounced form. On the other hand, the finer foliage of the cherry-fruited sorts may exhibit the most attenuated symptoms of the disease.

The Wisconsin Agricultural Experiment Station[2] in 1911 reported that the cherry and peach types of tomatoes were naturally resistant to the mosaic disease, and that crossing either of these with the variety Earliana gave strains resistant to the disease.

Although many distinct varieties have been observed and tested, the writer has found no variety of tomato immune to the mosaic disease of tobacco. The peach and the cherry varieties do not appear to show greater immunity than others, although it should be said that the finer foliage of these varieties may show symptoms of a very attenuated character. It is possible that this fact has led to the conclusion that certain varieties are more or less resistant or immune to the disease.

In 1910, Johanna Westerdijk[3] published an interesting account of the

[1] Notes on fungous diseases, etc , for 1908. Connecticut Agr. Exp. Sta. Bien. Rept. **1907–1908**: 857–858.

[2] Tomato breeding experiments Wisconsin Agr. Exp. Sta. Bul. 218: 20.

[3] Die Mosaikkrankheit der Tomaten. Amsterdam, 1910, 19 p. Mededeelingen uit het Phytopathologisch Laboratorium "Willie Commelin Scholten." Amsterdam 1.

mosaic disease of tomato. She concludes that this disease is infectious to tomatoes but that it is not communicable to tobacco. She is inclined to believe that the development of the disease is greatly dependent upon the intensity of light, and that strong sunlight increases the intensity of the symptoms. She also states that she was unable to communicate the mosaic disease of tobacco to healthy tomato plants by artificial inoculation.

Perhaps the most striking feature of Westerdijk's work is the conclusion that the mosaic disease of the tomato, in striking contrast to the mosaic disease of tobacco, is carried to the next generation of plants through the seed. Westerdijk's results in some respects are radically different from the writer's experiences with the infectious mosaic of tobacco and tomatoes. From the nature of these discrepancies one is led to wonder if the diseases investigated by Westerdijk are in reality identical with the mosaic diseases investigated by the writer.

EXPERIMENTS WITH PROGENIES OF MOSAIC-DISEASED TOMATO PLANTS

At the same time that the writer was making a study of the distribution of the virus in tobacco plants and its relation to the progeny of such plants, parallel experiments were performed with tomatoes and petunias affected with the same disease. As the following data show, the development of the disease in these plants is similar in all respects to the development of the disease in the tobacco plant.

In September, 1913, twenty-four plants were grown from seed of very badly mosaic-diseased tomato plants grown in pots. These seedlings were transplanted to a field where they were allowed to remain until full grown. At this time they averaged eighteen to twenty inches in height and every plant remained free from mosaic.

In a second experiment, seed of lot *A* from several large, badly mosaic-diseased plants were sown in a two-feet-square box, July 12, 1913. On August 2, 158 plants of this lot were transplanted to rich soil on a side bench in the greenhouse kept free from insects. On September 10, these plants averaged two to three feet in height and were full of blossoms and small, green tomatoes. Not a plant developed mosaic.

On July 15, eighty additional plants of the original lot *A* were transplanted to five inch pots and allowed to remain. On September 9, the plants, averaging two feet in height, were in full bloom and free from mosaic.

Fifty seedlings of the same lot were transplanted to the middle bench on August 2. These plants averaged eighteen inches to two feet in height and were in full bloom on September 9. None developed mosaic.

Ninety-five plants of the original lot were also allowed to grow undisturbed in the box in which they were germinated. These plants were in full bloom on September 8, and all remained free from mosaic.

In addition to these tests, thirty-four or thirty-five plants, from the original lot *A*, when young, were transplanted to the field. Many of these plants became diseased with mosaic. Another series of the same lot *A* was inoculated with the infective principle of mosaic. All these developed the disease ten to twelve days later. It may be stated here that the plants which were transplanted to the field in the immediate vicinity of a field of badly mosaic-diseased tobacco plants, became infested with aphids and flea beetles from the start. It is probable that these insects were responsible for the occurrence of the disease in these plants, since earlier investigations by the writer has shown that insects may become active disseminators of the virus of mosaic disease of tobacco.[4]

In a third experiment, 155 seedlings were grown from mixed seed of several large, mosaic-diseased tomato plants in pots. The seeds were sown July 9, and the young plants transplanted to a bed in the greenhouse August 2. On September 9, the plants averaged eighteen inches to two feet in height and were in full bloom. Throughout the experiments these plants were large, bushy and vigorous, and all remained free from mosaic.

In a fourth experiment, a mixed lot of seed *B* from several badly mosaic-diseased tomato plants, grown in pots, was sown September 15, 1913. These seedlings were grown as follows:

Thirty-two seedlings were transplanted to box No. 1, 12 inches square, September 30.

Thirty-two seedlings were transplanted to box No. 2, 12 inches square, September 30.

Thirty-six seedlings were transplanted to box No. 3, 12 inches square, September 30.

Thirty-six seedlings were transplanted to box No. 4, 12 inches square, September 30.

Fifty-two seedlings were transplanted to a bed in the greenhouse September 30.

Sixty-five seedlings were allowed to remain in the original box in which they were germinated.

These plants were allowed to grow unscreened in the greenhouse. A few aphids and an occasional flea beetle were noted on some plants. An examination of the several lots November 12 gave the following results:

[4] The mosaic disease of tobacco. U. S. Dept. Agr. Bul. 40. January, 1914.

Box No. 1, plants 18 to 20 inches high, budded or in bloom, one mosaic-diseased plant.

Box No. 2, plants 18 to 20 inches high, budded or in bloom, two mosaic-diseased plants.

Box No. 3, plants 18 to 20 inches high, budded or in bloom, no mosaic-diseased plant.

Box No. 4, plants 18 to 20 inches high, budded or in bloom, no mosaic-diseased plant.

Plants in the bed (52) averaged two feet in height, just blooming, one mosaic-diseased. Plants in the orignal box (65) averaged 18 to 20 inches in height, ready to bloom, none diseased.

In this test only four plants of the 253 grown to the blooming stage developed mosaic. There is every reason to believe that these plants developed the disease as a result of late, accidental infection, since symptoms did not appear until they were well toward maturity.

In a fifth test, 250 seedlings were grown from mixed seed of several badly mosaic-diseased tomato plants grown in beds in the greenhouse at Arlington, Virginia, during the season of 1913. The seed was sown on February 11, 1914. On February 27, the seedlings were transplanted as follows:

Fifty plants in ten rows of five each were transplanted to plot No. 1.

Fifty plants in ten rows of five each were transplanted to plot No. 2.

Fifty-eight plants were transplanted to 6-inch pots.

Twenty-two plants were transplanted to 3-inch pots.

Seventy plants were allowed to remain where germinated.

With a needle the fifty plants in plot No. 1 were inoculated with the virus of tobacco mosaic at many points on the leaves on February 27, March 3, 7 and 9. The twenty-two plants transplanted to three-inch pots were inoculated in the same manner on February 27 and March 3. The first inoculation of February 27, was made while the plants were in the cotyledon stage. Symptoms began to appear in nearly every plant ten to twelve days later. When examined on April 22, the plants were in full bloom and every inoculated plant in plot 1 and those in the three-inch pots had developed mosaic. Aside from these not a single plant in the uninoculated lots developed mosaic. From these tests it is safe to conclude that the infectious principle of mosaic did not exist in these plants prior to inoculation.

Although in the writer's experience no evidence of embryonic infection in the seed has ever been obtained, it would not be safe to assert that this never occurs. However, all evidence at hand indicates that it must be of very rare occurrence.

OCCURRENCE OF THE INFECTIVE PRINCIPLE IN THE FRUITS

Experiments have shown that the infectious principle of mosaic disseminates itself to all parts of affected tomato plants. The sap of the roots is quite as infectious as that of diseased leaves. The mature, healthy-appearing leaves of affected plants in which the disease has been long established, likewise carry the virus. Extensive experiments have shown that the juice of fruits at all stages of their growth carry the virus of the disease.

The following experiments demonstrate the presence of the virus in the green and ripe fruits of affected tomato plants as well as in the foliage.

On May 20, ten plants were inoculated with the extracted juice of a green tomato fruit from mosaic plant *A*. Four plants showed mosaic on May 28. Ten plants, as a control, were inoculated May 20 with the juice of a green tomato from a healthy plant. No mosaic developed.

On May 20, ten plants were inoculated with the extracted sap of a green tomato fruit from mosaic-diseased plant *B*. Nine plants showed mosaic on May 28 and 29. Ten similar plants inoculated on the same date and in the same way with the sap of leaves of the same plant *B* gave four plants with mosaic on May 28. Ten similar plants, as a control series, were inoculated on May 20, with the extracted juice of a green, healthy tomato fruit. No mosaic developed.

On June 2, ten plants inoculated with the extracted juice of a fully ripened, red tomato from mosaic-diseased plant *B* in the preceding tests. On June 10 two plants showed mosaic. Ten plants inoculated on the same date with sap of the leaves of plant *B*, on June 10 gave six plants with mosaic. As a control, ten plants were inoculated on June 2, with the juice of a green fruit from a healthy plant. No mosaic developed.

On June 6, ten plants were inoculated with the extracted sap of a green tomato from mosaic-diseased plant *C*. On June 11 five plants had developed mosaic. On June 6, ten plants were inoculated with the sap of leaves from the same plant *C*. On June 11 six plants showed mosaic. Of ten control plants inoculated on June 6 with the sap of a green fruit and leaves of a healthy plant, none developed mosaic.

On June 24, ten plants were inoculated with the extracted juice of a ripe tomato from mosaic-diseased plant *D*. On June 30, five plants had developed mosaic. Of ten controls inoculated with the juice of a ripe tomato from a healthy plant, none developed mosaic.

All tests with the extracted juice of green and ripe fruits of mosaic-diseased plants have shown that the virus of the disease is disseminated throughout the fruits as well as the foliage and roots. Although ripe, red fruits likewise contain the virus, experiments seem to indicate that

inoculations in some instances are, perhaps, less certain when such fruits are used than when green ones are used. However this may be, the virus sooner or later becomes distributed more or less abundantly in the fruits, both green and ripe.

Although the virus is present in the fruit, it appears to produce no appreciable change in the development of the usual red color in ripening fruit, similar to the mottling produced in the pink or red blossoms of tobacco plants. The yellow color of the blossoms of tomato plants likewise does not seem to be modified by the disease.

FIG. 1. At left healthy tomato plant; at right mosaic-diseased tomato plant of same age obtained by inoculation from mosaic-diseased tobacco.

INCUBATION PERIOD OF THE VIRUS

As in tobacco, the incubation period of the mosaic virus in tomato plants is greatly dependent upon the age, vigor and growth conditions of the plants. Young, rapidly growing plants show visible symptoms more quickly than old plants. Inoculation experiments with tomato plants at different seasons have given the following results:

Seven good-sized plants, several weeks old, were inoculated with the virus of tobacco mosaic on December 21, 1912. First symptom in fifteen days.

Nine good-sized tomato plants, several weeks old, were inoculated with the virus of tobacco mosaic on June 11, 1913. First symptom in seventeen days.

Seventy-two young tomato plants were inoculated with the virus of

tobacco mosaic on February 27, 1914, while in the cotyledon stage and on several subsequent dates. The earliest symptoms were showing ten to twelve days afterward.

Under conditions favoring rapid growth, visible symptoms of mosaic may appear in young plants inoculated with the virus even more quickly than this. Although the leaves may show marked symptoms of disease when very young, the mottling and distortion frequently becomes less pronounced as the leaves become older. The writer has never known a

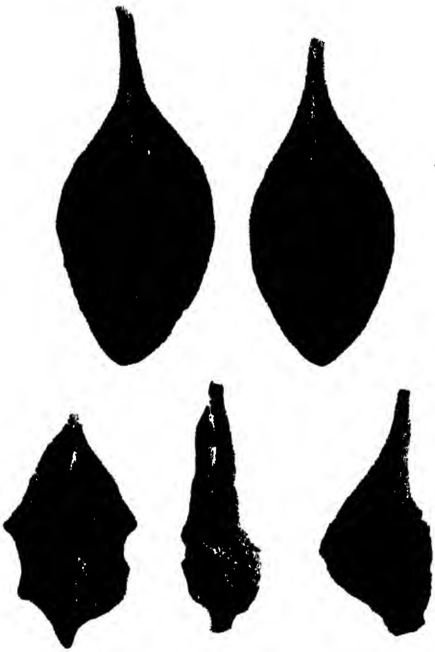

FIG. 2. Above, leaves from healthy petunia plant; below, leaves from mosaic-diseased petunia plant obtained by inoculation from mosaic-diseased tobacco, showing dark green swellings along the midrib. Natural size.

mosaic-diseased tomato or petunia plant to recover from the disease. Although visible symptoms may be so slight as almost to escape notice, the virus of mosaic is still abundantly present in the plant. Under these conditions, a renewal of growth by cutting back brings a renewed expression of symptoms coincident with the growth of new shoots. Experiments have shown that healthy tomato or petunia plants may be cut back indefinitely without producing mosaic, provided accidental infection is prevented by thorough methods of sterilization and the exclusion of all insect carriers.

In comparison with the same disease obtained by inoculation with the virus of mosaic-diseased tobacco, tomato or petunia plants inoculated with the virus of other solanaceous plants affected with the mosaic disease of tobacco, show no appreciable difference in the incubation period, character of symptoms, and so forth.

PETUNIA PLANTS AFFECTED WITH THE MOSAIC DISEASE

Experiments with petunia plants affected with the mosaic disease of tobacco have also shown that the virus is present in the roots, foliage, stems, green capsules and corollas of mosaic-diseased plants. Since in tests with the capsules, the entire capsule, including the ovary walls, placenta and seed were macerated together, it is impossible to state whether or not the virus reaches the ovules themselves, as is the case with the mosaic disease of tobacco. The seed appears to develop in such capsules quite as normally and as abundantly as in healthy plants. As is the case with tobacco and tomatoes, the seed of mosaic-diseased petunia plants, in the writer's experience, has always produced healthy plants.

Owing to the smaller, thicker leaves and the less evident vein development, the leaves of mosaic-diseased petunia plants do not usually show the beautiful dark green reticulations and mottlings so characteristic of the mosaic disease of tobacco. The leaves are frequently distorted, crinkled or curled, and show large, irregular, dark green areas along the midrib (fig. 2).

As in the case of tobacco, the blossoms of mosaic-diseased petunia plants also show the effect of the disease, sometimes becoming more or less imperfect or depauperate in some portion of the corolla. The uniform color of the blossoms, more especially the pinks and reds, may be broken into lines and patches, or decreased in intensity. In the petunia, however, the blossoms never show the beautiful mottling so frequently seen in the blossoms of affected tobacco plants.

With the exception of slight variations in the external symptoms it is evident that the mosaic disease of tobacco affects the petunia and the tomato in quite the same manner that it affects the tobacco plant. As in the case of tobacco, the virus is disseminated in all parts of the plant but does not appear to be transmitted to the progeny through the seed.

OFFICE OF TOBACCO AND PLANT NUTRITION INVESTIGATIONS
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NOTES ON AN ARTIFICIAL CULTURE OF RHIZOCTONIA CROCORUM

William W. Diehl

With One Figure in the Text

In a recent publication Duggar[1] mentions the lack of success that has thus far attended attempts to cultivate the violet Rhizoctonia, *R. crocorum* (Pers.) DC., on an artificial medium. It is thought that a record of its successful culture and of the methods employed together with a preliminary description of its cultural characters might be of some use to those investigators interested. It is of interest in view of the increasing prevalence in America of the disease associated with this fungus.[2]

In the fall of 1911 several unsuccessful attempts were made at cultivating this Rhizoctonia by placing material from the diseased host on petri dish plates of the following media: rice agar, synthetic agar,[3] Thaxter's potato hard agar, and a similar medium using alfalfa-root decoction as a base. No growth of Rhizoctonia was observed, although other mould growths, chiefly species of Fusarium, were in abundance. On November 30, 1914, bits of bark, about five millimeters in diameter, covered with a mesh of violet hyphae, were thoroughly washed in sterilized tap water, then placed upon moist sterilized (steamed) rice in tubes. There developed a cottony mass of mold. Frequent examinations of material from the surface of cultures during two weeks incubation failed to show the presence of a violet mycelium of Rhizoctonia. But in twenty-seven days a pinkish violet color became apparent on the medium. Microscopic examination of this material showed Rhizoctonia-like hyphae with contaminating fungi and bacteria.

[1] Duggar, B. M. Rhizoctonia crocorum (Pers.) DC. and R. Solani Kuhn (Corticium vagum B. & C.) with notes on other species. Ann. Mo. Bot. Gard. **2**: 403–458. f. 1–4. S. 1915.

[2] *Rhizoctonia crocorum* (Pers.) DC. was found in Iowa for the first time during the summer of 1911 on the farm of Mr. Charles Lau near Davenport, and reported to Dr. L. H. Pammel by G. R. Bliss.

[3] Synthetic agar: water 1,000 cc.; dextrose, 100 gm.; peptone, 20 g.; dipotassium phosphate, 2.5 g.; calcium chloride, 0.1 g.; potassium nitrate, 2.5 g.; ammonium nitrate, 2.5 g.; magnesium sulfate, 5 g. This so-called synthetic agar here used is an adaptation of the medium described in Darwin and Acton's Practical Physiology of Plants, 68 (ed. 3) and of that used by F. V. Rand in Jour. Agr. Res. **1**: 305. Ja. 1914.

To secure the organism in pure culture detached masses of hyphae from the material on rice were placed on petri dish plates of various agar media on January 1, 1915. Growth of a violet Rhizoctonia was obtained only upon plates of "radicicola" agar[4] acidulated with acetic acid. Acidulation was accomplished by adding the correct amount of sterilized acid with a sterilized pipette to the medium at the time of pouring the plate. Ten degrees of acidulation were used: 1.0 to 10., using the scale of the Standard Methods of Water Analysis.[5]

Most satisfactory results were obtained with the medium acidulated to 5. At this reaction the spores of the contaminating Fusarium did not germinate, while the extension of contaminating hyphae was somewhat inhibited, and no bacterial growths developed; yet the Rhizoctonia grew apparently with slight inhibition. From projecting hyphae, March 17, 1915, two cultures on "radicicola" agar were obtained: one a culture contaminated by a single type of Fusarium, the other a pure culture.

The growth of the violet fungus in the culture contaminated by the Fusarium resembled that in the original culture; i.e., in thirty days a violet web of Rhizoctonia and Fusarium hyphae was evident at the surface of the medium. Microscopic examination of the fungus showed hyphae similar to young vegetative hyphae from the diseased host. Violet pigment from the fungus by this time was dispersed through the medium to a depth of about one centimeter. That this pigment came from the Rhizoctonia alone was proved by cultures of the contaminating Fusarium which developed no pigment. Though of slow growth, transfers of this culture to "radicicola" agar have continued with but slightly lessened vitality. Transfers were made on July 22, 1915, to sterile alfalfa-root plugs, made by inserting pieces of alfalfa root over moist absorbent cotton and then autoclaving. The culture tubes were sealed with waxed cotton plugs and incubated for twenty weeks. Various inspections during the first six weeks showed the plugs covered by Fusarium. After twenty weeks incubation the Fusarium growth had subsided, while in some instances from one-half to all of the surface of the medium was covered by the purple-black layer of the Rhizoctonia. The absorbent-cotton plug below the medium was also permeated by the mycelium of the fungus. Microscopic examination of the medium showed the fungus to be present only on and in the cortex and in the central pith of the alfalfa-root plug. This type of growth is almost identical with that of the fungus upon alfalfa roots in the field. But while the culture showed

[4] Radicicola agar: water, 1000 cc.; saccharose, 10 g.; dipotassium phosphate, 1.0 g.; agar agar, 20 g. Lipman, J. G. and Brown, P. E. A laboratory guide in soil bacteriology. 76. 1911.

[5] Report of Committee on Standard Methods of Water Analysis. 106. Ja. 1905

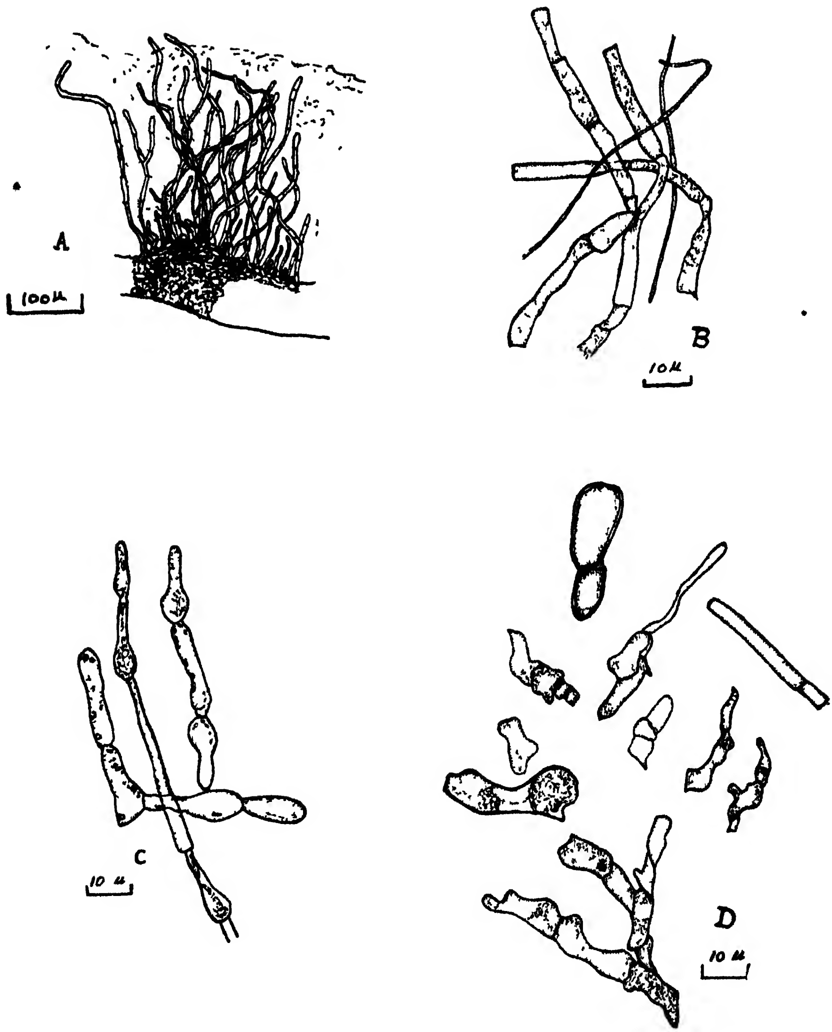

FIG. 1. *A*, Section of cortical surface of an alfalfa-root plug culture of Rhizoctonia with contaminating Fusarium, the latter represented by the shaded area about and between the loose aerial hyphae of Rhizoctonia. *B*, Detail of *A;* the hyphae of small diameter representing the contaminating Fusarium. *C*, Young vigorous hyphae of Rhizoctonia from a Fusarium—contaminated culture on "radicicola" agar. *D*, Hyphae of Rhizoctonia from pure culture.

best growth on "radicicola" agar, sterilized rice, alfalfa root plugs, and synthetic agar, it grew less vigorously upon the following media: rice agar; Thaxter's potato hard agar; alfalfa-root agar (made on the same principle as the potato agar, but using alfalfa roots in place of potato); alfalfa broth (using the same weight of alfalfa leaves and stems as of potato in potato agar and on the same basis without the addition of agar agar); sterilized plugs of elder pith; sterilized plugs of moist absorbent cotton; and sterilized silt loam soil. No growth of Rhizoctonia developed from transfers made at four different times to dextrose broth, dextrose agar, bean agar, and alfalfa agar (made by adding 30 grams of agar agar to the alfalfa broth above described). There was no apparent relation of various temperatures to this culture as exhibited in forty days growth on "radicicola" agar, Thaxter's potato hard agar, and alfalfa-root plugs at 10°, 20°, 22° to 25°, 30°, and 37°C.

The organism in pure culture was grown with some degree of success only on "radicicola" agar. Only two successful transfers have been made—on April 2 and on June 29, 1915. The growth was very slow, barely noticeable in thirty days. The hyphae although somewhat similar in form to those in the contaminated culture, were arranged in a very dense mat; usually these hyphae were similar to those found in sclerotia upon the diseased host. These hyphae, often partially disintegrated, were of a brownish rather than of a violet color; and but slight tendency of the pigment to dissolve in the medium could be observed. The culture tubes were sealed with waxed plugs to prevent further evaporation and were incubated for a period of twenty-four weeks. Of five original transfers to "radicicola" agar the one in which the inoculating material was submersed between the medium and the glass alone showed growth. Several masses of hyphae were grouped in this area. The largest hyphal mass was three millimeters in diameter with a few fine rhizomorph-like strands extending to a distance of two millimeters from the border. In the case of the material incubated for twenty-four weeks upon the surface of "radicicola" agar no increase in the size of the mycelial mass was observed. Microscopic examination of this material showed some new hyphae to be present. Most of them were largely disintegrated indicating a partial autolysis. The latter was true of material incubated for thirty-two weeks upon the bark of sterilized alfalfa-root plugs and upon the other media enumerated in the description of the contaminated culture.

Inoculation of healthy alfalfa plants by placing material from cultures on and within the bark of the roots failed to produce the disease. However, this can hardly be considered as an indication of a lack of virulence in the fungus, since under the same conditions (in greenhouse) no infec-

tion resulted in plants inoculated with fresh material from the diseased host.

That the fungus obtained in culture is considered to be the same as that present on diseased alfalfa is based on the origin of the culture, the morphology of the vegetative hyphae, the character of the contaminated culture on alfalfa-root plugs, and the diffusion of the violet pigment through an acidified agar medium. This last character resembles that of the pigment from hyphae, which is observed by Duggar to dissolve in acidulated water.

The results from artificial cultivation thus far show the violet Rhizoctonia to be of very slow growth upon the media used; and the peculiar cultural characters of this organism indicate that its metabolism, in artificial culture at least, is affected by an accompanying species of Fusarium.

All the cultures described, except where otherwise noted, were kept in a dark closet at room temperature.

The work was done at the instance of Dr. L. H. Pammel and under his direction. Thanks are due to him and to others for suggestions and to Mr. Charles Lau of Davenport, Iowa, who has generously given his time in obtaining material for use.

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A BACTERIAL DISEASE OF WESTERN WHEAT-GRASS, AGROPYRON SMITHII

Occurrence of a New Type of Bacterial Disease in America[1]

P. J. O'Gara

With Plates IX, X, XI, XII, and XIII

INTRODUCTION

In a note published in *Science*[2] the writer indicated some of the principal facts concerning this disease which was found[3] for the first time in the Salt Lake Valley, Utah, in June, 1915. Later the writer collected specimens in Salt Lake County in the vicinity of Murray. Specimens were also collected in Utah County at a distance of some twenty-five miles to the south of the locality where the first specimens were found. Good material was very abundant. Examination of these specimens showed that the inflorescence was covered with a primuline yellow[4] ooze which hardened on drying. An examination of the yellow slime taken from between the glumes and the floral organs showed that it was composed almost entirely of bacterial organisms. Under humid conditions the ooze was so viscid that the heads of the wheat-grass, when grasped, would stick to the hand. Studies were made of the organism during the season of 1915, the results of these studies being given herewith.

THE DISEASE

The characteristic appearance of the disease is such that it at once suggested a striking similarity to the disease of orchard grass (*Dactylis*

[1] Paper read before the meeting of the American Phytopathological Society, Columbus, Ohio, December 28, 1915. Abstract published in Phytopathology **6**: 98–99. 1916. Some additions have been made to the paper since the original was read.

[2] Science, n. s. **42**: 616–617. October 29, 1915.

[3] The first specimens were brought to the laboratory by Mr. W. W. Jones, botanist in the Department of Agricultural Investigations, American Smelting & Refining Co.

[4] Ridgway, Robert. Color Standards and Nomenclature, 1912 edition. All references to color made in the text refer to this author.

glomerata L.) which was discovered by Rathay[5] and which has been given further study by Dr. Erwin F. Smith.[6] Generally, affected plants are somewhat dwarfed but the most striking characteristic of the disease is the presence of enormous masses of surface bacteria which form a primuline yellow ooze or slime which produces layers between the stem and the upper sheath and between the glumes of the inflorescence. The floral organs are also extensively occupied by the organism. The bacterial ooze also collects on the outer or exposed surface of the glumes and sheaths in globules which, on drying, become hard and brittle. These globules, on weathering, become orange rufous and if held to the light have the appearance of particles of resin. This hardened slime dissolves readily in water, producing a milky appearance. Knee-shaped bendings are often produced in the stem just above the upper node and these often protrude through the sheath. This phenomenon usually occurs when the space between the upper internode and its surrounding sheath is occupied by a deep layer of the primuline yellow bacterial slime. The organism does not penetrate into the tissues until some time after it has covered the surface. It is later found in the substomatic chambers and in the intercellular spaces, but it has not been found occupying the cells. The infected inflorescence rarely ever produces normal, germinable seeds. Thousands of infected spikelets have been examined and in no case have fertile seeds been found in them.

In so far as the writer has been able to determine, this disease of western wheat-grass has not been heretofore reported in the United States. Previous to June, 1915, it had not been observed by anyone in the Salt Lake or Utah Valleys and it is therefore presumed that the disease is a new one. Several common names have been suggested for this disease but the one which seems to be the most satisfactory is the *yellow gum disease* of western wheat-grass.

Whether or not the disease is of any economic importance remains to be seen. It is well known that western wheat-grass propagates itself largely by means of root stocks and the production of seed is therefore of less importance than it otherwise would be. However, the food value of the plant is usually lessened in a certain degree inasmuch as seed is not formed where the inflorescence is attacked. Furthermore, the plants are more or less dwarfed by reason of the early attack of the organism. It has been stated that western wheat-grass does not usually produce an

[5] Rathay, Emerich, Über eine Bakteriose von Dactylis glomerata L. Sitzber. Wiener Akad., Abt. 1, **108**: 597–602. 1889.

[6] Smith, Erwin F. A new type of bacterial disease. Science, n. s. **38**: 926. December 26, 1913.

Bacteria in relation to plant diseases, Vol III, August 4, 1914.

abundance of matured seed. However, the writer has had occasion to examine non-infected areas for the purpose of making comparison as to the quantity of seed produced. In the Salt Lake and Utah Valleys fertile seeds are generally present in considerable amount in healthy plants, whether they are found growing in the richer, moist soils of the valleys or higher up on the dry, unirrigated foot-hills.

Plants affected with the disease are found in the open and this is in striking contrast to the disease of orchard grass discovered by Rathay, where only shaded plants were found to be infected. The same amount of infection was found in the more moist soils as in the dry, unirrigated soils so that the habitat of the host plant does not seem to have any particular bearing on the disease. This point, however, demands further observation.

Careful examination of many other species of grasses has not been rewarded with the finding of a similar disease. In stands of mixed grasses the western wheat-grass was the only one found to be infected. Whether the organism is pathogenic to other species of wheat-grass is not known. Owing to the fact that other work prevented the writer from carrying out certain experiments little is known as to the manner of natural infection. It is not known how the organism enters the plant, but it is possible that it is carried by insect agencies. The matter of artificial infection will not be discussed here.

A white organism, which has not been given careful study, has been found to be associated with the yellow organism. In most platings the white organism has appeared but always in very small numbers. The association of the white organism with the yellow organism in cultures does not seem to influence the growth of the yellow organism. This is true so far as observed in surface growths on solid media.

THE ORGANISM

The organism being non-motile is referred to the genus Aplanobacter, and not agreeing in general with any previously described organism, the specific name *Agropyri* is suggested. It is therefore recorded as

Aplanobacter Agropyri sp. nov.

Morphology

Vegetative cells. The organism is a short rod with rounded ends. It is found singly or in pairs and infrequently may occur in chains of four. Organisms taken from four-day and fifteen-day sugar beet and potato cultures when stained with carbol-fuchsin are 0.4 to 0.6 by 0.6 to 1.1μ.

Those taken directly from the plant are usually a trifle smaller but in the main the organism taken from the plant and from various cultures seems to maintain a size practically within the limits given.

Endospores. No endospores have been observed.

Flagella. Many attempts have been made to demonstrate flagella from various cultures, using Moore's as well as Loeffler's methods, but without success.

Motility. The organism has been examined in agar hanging blocks and in beef broth hanging drops, but no distinct motion has been observed. Owing to the very characteristic viscid growth on various media it is perhaps quite certain that the organism is not motile.

Capsules. Capsules have been frequently demonstrated by Ribbert's and by Welch's methods. The organisms used for this purpose were grown on neutral nutrient agar and on potato and sugar beet slants.

Zoogloeoe. Zoogloeoe have not been seen in cultures of bouillon. On a few tubes of milk and litmus milk some very small floating zoogloeoe-like bodies were found.

Involution forms. No involution forms have been observed.

Staining reactions. The organism stains readily with such stains as methylen blue, anilin-gentian-violet, and carbol-fuchsin. The latter stain produces beautiful results.

Gram's stain. Many efforts at staining were made with Gram's method but the results hardly warrant a conclusion. As a rule the stain was never completely lost nor was it ever retained in the original intensity. The anilin-gentian-violet and iodine solutions were used for two minutes and the preparations were then treated with absolute alcohol for three minutes. The mounts washed in alcohol lost a great deal of their intensity as compared with those not treated with alcohol and consequently the organism must be regarded as Gram-negative.

Acid-fast. The organism is not acid-fast.

Cultural characters

The first attempts at isolating the organism were uniformly unsuccessful. This was undoubtedly due to the viscidity of the slime, as has been noted in the isolation of other organisms which have the same characteristic. For the purpose of isolating the organism poured plates were made in various agars, but the one which was finally found to be best suited is neutral nutrient agar. Agar with a reaction of +15 did not seem to give good results as compared with the neutral agar. In order to make isolations it was found necessary to use a considerable quantity of the inoculum. Very thinly sown plates as a rule produced no colonies.

When sufficiently heavy sowings were made colonies began to appear in about eight days at temperatures of about 25°C. The same difficulty in the inoculation of liquid media was encountered. Unless a rather large number of bacteria were used the cultures failed altogether. This was particularly true of bouillon, milk and the various sugars used for fermentation studies. No perceptible odor could be detected in any of the culture media used.

After the organism has been cultivated in the laboratory for some time it is found that subcultures show a much more vigorous growth than when the organism is first isolated from the infected wheat-grass. Cultures made from these subcultures show very marked growth in all culture media that have so far been used.

Nutrient neutral agar colonies. When plantings were made in nutrient neutral agar plates, either directly from the host plant or from other culture media, liquid or solid, the colonies usually appeared in about eight days when incubated at a temperature of about 25°C. These colonies were globular and lenticular in form. The growth was very slow and as a rule surface colonies made very little progress and did not tend to spread very much from the centre. The surface of the colonies was generally slightly roughened and concentrically ringed. The growth was opaque and raised, with the edge more or less beaded or irregular. Under very moist conditions the colonies were generally much smoother both as to surface and edge. The color of these colonies after considerable growth became primuline yellow. The growth was very viscid. No liquefaction took place.

Nutrient neutral agar streaks. On slanted agar tubes a streak made with a platinum needle developed a somewhat slow growth. The streak widened toward the bottom of the slant but very little or no growth took place beneath the surface of the water of condensation. However, a primuline yellow precipitate in considerable amount was formed in the "V". The growth is so slow that under most conditions it rarely ever covers the surface of the slant, excepting near the bottom and above the water of condensation. At the upper part of the slant the growth is sometimes beaded; the streak is opaque, raised and glistening, being of a primuline yellow color. There seems to be no change in the color of the medium beneath the bacterial growth. The growth is very viscid and a platinum needle touched to it and then lifted, readily demonstrates this characteristic. Under proper conditions of moisture the growth usually has a glistening appearance. No liquefaction took place.

Nutrient neutral agar stab. In stab cultures practically no growth took place along the line of puncture beyond a distance of a few millimeters from the surface. The surface growth was slow at first but later (after

one month) covered the greater portion of the tube. This growth had a glistening appearance and was more or less contoured with the outer edges somewhat wrinkled. The growth was very viscid. There was no liquefaction of the agar.

Gelatin colonies. On neutral gelatin plates at about 20°C. the colonies appeared in eight to ten days as minute, globular or lenticular, whitish spots. Growth was extremely slow and the medium usually became very dry before there had been any considerable surface growth. Gelatin seems to be a decidedly poor medium for the organism. The color of the gelatin colonies was that denoted as mustard yellow, or perhaps a little lighter shade of yellow. There was no liquefaction of the gelatin during the period of observation. The growth in the gelatin plates was so poor that it cannot be said to have any particular characteristics.

Gelatin streaks. On slanted neutral gelatin at 20°C. streaks with a one millimeter loop developed very slowly, and never became much elevated as was the case in other media. After one month the growth was about three millimeters wide at the bottom and did not increase above the width of the original stroke at the top of the slant. The edges of the streak were more or less uneven; the growth was viscid; the surface was glistening; the color was mustard yellow or lighter in the thin portions of the streak.

Gelatin stab. In the gelatin stab at 20°C. the path of the needle became slightly beaded in the upper twenty-five millimeters of the medium in about ten days. There was no apparent growth at the bottom of the stab. The surface growth at the end of ten days was about four millimeters in width, the edges being slightly beaded and sometimes lobate. Under proper moisture conditions the growth was very much smoother than where the culture medium lacked sufficient water. The growth was viscid but scant. There was no liquefaction of the gelatin in seven weeks or in cultures held for four months.

Potato plugs. Potato plugs were inoculated with a platinum needle from agar colonies which were approximately two weeks old and kept at a temperature of about 25°C. At the end of about two days a light, mustard yellow, opaque streak developed along the path of the needle. There was a moderately good growth along the streak but it did not spread to any considerable extent at the upper or drier portion of the slant. At the lower portion of the slant near the surface of the water the growth was more spreading. At the end of ten days the growth at the upper end of the tube was approximately two millimeters in width, much raised and somewhat beaded along the edges, and of a primuline yellow color. The lower portion of the streak showed a more glistening surface or moist appearance and did not have the beaded character of the upper part of the streak. The surface of the upper part of the streak

was somewhat beaded or papillate. The growth tends to pile up and become elevated considerably above the surface of the slant. Cultures a month old become much darker, the color becoming very nearly raw sienna. The surface of the growth retained its papillate character. In some cases the surface of the growth had a shagreened appearance. The growth was very viscid, except in the upper portion of the slant where, owing to drying, it had a cheesy consistency. There was no perceptible odor and the substratum was not grayed. The potato is one of the best media for the cultivation of this organism. As a matter of fact, it was found to be much easier to isolate the organism by means of sterilized potato slices in petri dishes than by the use of agar plates. Thin flakes of the hardened bacterial ooze were separated from between the glumes and floral organs of infected spikelets. These were placed in droplets of sterilized, distilled water and the surface of the potato slices was streaked with a platinum needle which had been dipped in the water. By passing the needle repeatedly over the potato slices the sowing produced by the last strokes was very thin and from the colonies which developed in these thin streaks pure cultures were obtained.

Sugar beet. Plugs and slices of sugar beet were used in the same way as potato. The growth of the organism was practically the same although the color was sometimes a trifle lighter, being nearly mustard yellow. The edges of the streak as a rule were not so much beaded or papillate and the same was true of the surface. The growth was generally somewhat moist or glistening in appearance and always viscid. There was no perceptible odor.

Bouillon. Peptonized bouillon was made from carefully selected round-steak and was then made neutral according to Fuller's scale, it having been found that the organism grew best on neutral media, at least so far as our experiments have gone. Inoculations were made from a ten-days-old potato-tube culture, a small quantity of the viscid ooze being first put into a droplet of water and thoroughly distributed. Several one-millimeter loopfuls of bacteria were then transferred to the bouillon tubes and the cultures incubated at 25°C. The medium was slightly clouded after forty-eight hours. The clouding never increased to any great extent and at the end of ten days a light mustard-yellow precipitate began to form. At the end of twenty days the culture was practically cleared, with considerable light, mustard-yellow precipitate. There was no ring or pellicle formed. By twirling the culture between the hands the viscid slime at the bottom of the tube arose in stringy masses which did not tend to mix readily with the clear liquid. There was no perceptible odor.

Beef extract bouillon. This medium was not used.

Milk. Freshly drawn, throughly centrifuged milk, titrating +24 on Fuller's scale, was inoculated, without neutralizing, with bacteria in a

manner similar to that in which the bouillon tubes were inoculated, and the cultures kept at 25°C. There was no perceptible change in the milk for one month. The milk cultures remained the same as the milk in the check tubes with the exception of a primuline yellow precipitate. In only one or two tubes out of a dozen was there any appearance of zoogloeoe-like bodies or a surface ring. At the end of three months there was a primuline yellow precipitate about three millimeters deep and a surface ring of the same color approximately one-half centimeter wide. In four months the ring had widened to two centimeters with no increase in quantity of precipitate. There was a change in the consistency of the milk due to evaporation. No odor could be detected. The color of the milk at the end of three months remained the same as in the check namely, a very light, ivory yellow. Caesin was not precipitated. Titration showed the cultures to be +28 on Fuller's scale, showing increased acidity. At the end of four months there was no change in the color of the milk, but some casein was precipitated.

Litmus milk. Milk from the same stock was used in preparing the litmus milk tubes. Transfers were made in the same way. The color of the litmus milk as made up was very nearly wistaria blue. At the end of about one month there was a viscid, primuline yellow precipitate, approximately three millimeters deep. In two tubes there was an imperfect, mustard yellow ring and the appearance of small zoogloeoe-like bodies. A very slight reduction of the litmus had taken place. In tubes three months old some reduction took place in the color, which became a very light campanula-blue, but at the end of ten days thereafter most of the original color returned. It was also found that the original color could be partially restored by a vigorous twirling or shaking of the tubes. In four months the ring had slightly widened and the precipitate was somewhat increased. The litmus was practically all reduced, only a half centimeter ring at the upper end of the tube remained, the color being pale Hortense violet. The portion below the colored ring became cartridge buff and of thick consistency due to evaporation. The growth in the litmus milk tubes was of the same viscid nature but there was no change in the consistency of the medium excepting that due to some precipitation of casein. There was no perceptible odor. The titration showed that the amount of acid liberated was the same as in the milk tubes as shown above. Milk is an excellent medium for the culture of this organism. Vigorous growth was obtained on potato slants when inoculated from milk tubes six months old.

Physical and biochemical characters

Fermentation tubes. A basal solution was made up by adding 1 per cent Witte's peptone to filtered tap water. Four solutions were made from this,

each containing, respectively, 2 per cent of one of the following carbon compounds: glycerine, saccharose, dextrose and lactose. Five fermentation tubes were filled with each of these solutions and sterilized by heating for twenty-five minutes on three successive days. Three tubes of each set were inoculated and two were left as checks. The tubes were inoculated in the same way as has been described for other fluid media. After about three days the open end of the tubes in all of the solutions was slightly clouded. This cloudiness increased up to about fifteen days in most of the tubes. The line of demarcation between the clear liquid in the closed arm and in the open arm was not very clearly marked. However, there was no apparent cloudiness beyond the narrow neck of the tubes. In each case there was a slimy precipitate at the bottom of the open arm, somewhat resembling the precipitate formed in the bouillon tubes. The fact that no growth occurred in the closed arm of the fermentation tubes tends to point strongly toward the aerobic nature of the organism. This is further shown by the fact that the organism did not tend to grow at the bottom of the agar or gelatin stabs. The cultures were tested for acidity after they had grown for eighteen days. Another lot was tested for acidity at the end of four months. At the end of eighteen days the tubes titrated (Fuller's scale) as follows: saccharose +5, dextrose +8, lactose +4, glycerine +5. The check tubes showed a reaction of +0.5. At the end of four months the saccharose medium titrated +9, dextrose +11, lactose +8. The glycerine medium in fermentation tubes was not tested at the end of four months. No gas was formed in the closed arm of any of the fermentation tubes. There was no perceptible odor.

Nitrates. Six tubes, each containing ten cubic centimeters of peptonized beef broth, to which had been added 1 per cent nitrate of potash, were used. Two tubes served as a check and four were inoculated in the same manner as previously described for other liquid culture media. At the end of five days the tubes were considerably clouded and were then tested for nitrates in the following manner: To each culture one cubic centimeter of boiled starch water and one cubic centimeter of potassium iodide solution (1–200) were added. Upon adding a few drops of strong sulphuric acid water (2–1) the cultures immediately became blue-black, showing that free iodine had been liberated. The starch solution and the potassium iodide water had been freshly prepared and were carefully tested before being used by making use of the checks as well as by testing the reagents independently.

Diastatic action. The test for diastatic action was made on scrapings from potato slants. Potato cultures about three months old were taken and the culture covering the surface carefully removed. Scrapings were

then taken from the surface, which had not been grayed, and crushed in a porcelain mortar with a few cubic centimeters of water. Upon adding a weak solution of iodine in potassium iodide a very beautiful purplish color appeared, showing that diastatic action had taken place. Check tubes of the same age were tested in a similar manner when a blue color resulted.

Thermal death point. The thermal death point has not been carefully determined, but is probably not far from 50°C.

Optimum temperature. The optimum temperature for this organism appears to lie between 25° and 28°C.

Maximum temperature. The maximum temperature has not been carefully determined.

Sensitiveness to drying. No direct tests were made of the organism dried on carefully sterilized cover slips, but material taken from dried glumes which had been in the laboratory eleven months showed vigorous growth when inoculated into the proper media. Under this condition it would seem that the organism retains its vitality for a considerable length of time, perhaps a year or more.

Group number

The group number, according to the descriptive chart of the Society of American Bacteriologists, is 212.2223522.

Natural infection

As indicated in the first paragraphs, little or nothing is known concerning natural infection. It may be stated, however, that work along the line of determining how natural infection occurs is under way and these studies will be reported later.

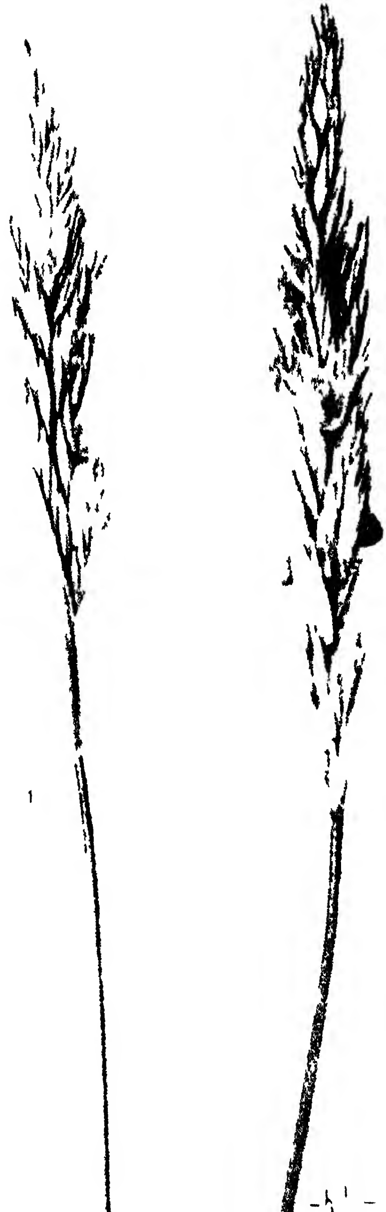
Pure cultures of the organism, as well as material which has been collected in the Salt Lake and Utah Valleys, will be sent upon request in so far as the supply will permit.

DEPARTMENT OF AGRICULTURAL INVESTIGATIONS
AMERICAN SMELTING AND REFINING COMPANY
SALT LAKE CITY, UTAH

EXPLANATION OF PLATE IX

FIG. 1. Inflorescence of *Agropyron Smithii* showing natural infection produced by *Aplanobacter Agropyri*. One and one-third times natural size. Specimen collected near Murray, Salt Lake County, Utah, June 29, 1915. Original.

FIG. 2. Inflorescence of *Agropyron Smithii* showing natural infection produced by *Aplanobacter Agropyri*. One and one-third times natural size. Specimens collected near Murray, Salt Lake County, Utah, August 23, 1915. Note the darker color of the bacterial ooze due to weathering. Original.



1 2

O'GARA: APLANOBACTER AGROPYRI

Explanation of Plate X

Fig. 1. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when four months old. Original.

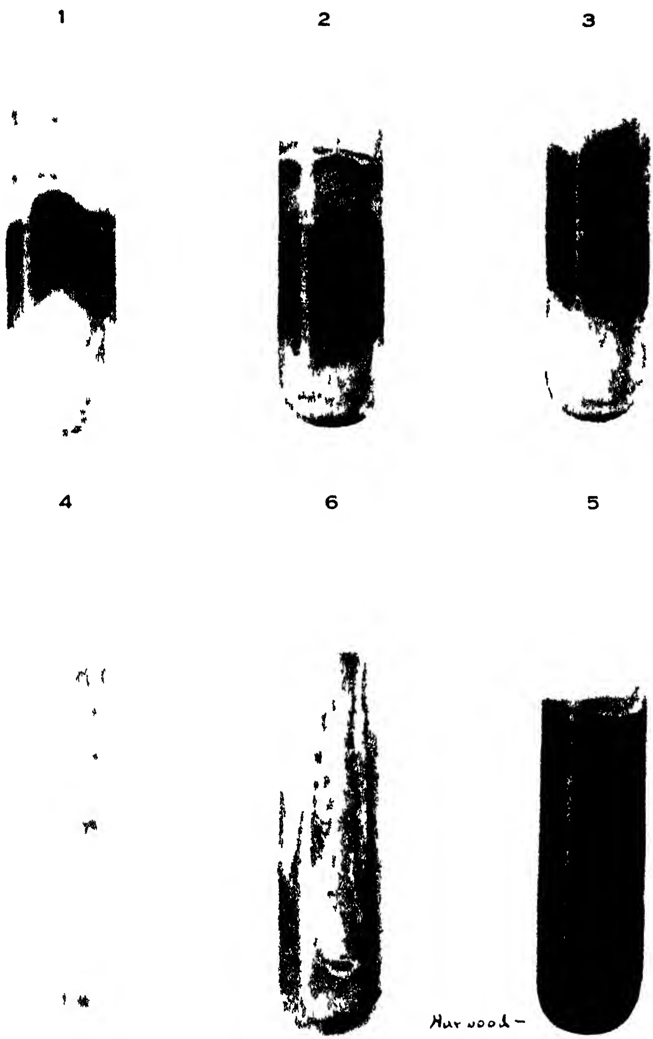
Fig. 2. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when three months old. Original.

Fig. 3. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when three and one-half months old. Original.

Fig. 4. Milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when four months old. Original.

Fig. 5. Check tube of litmus milk. Original.

Fig. 6. Potato slant culture of *Aplanobacter Agropyri* incubated at a temperature of 20°C. Painted when twelve days old. Original.



O'GARA APLANOBACTER AGROPYRI

Explanation of Plate XI

Fig. 1. Photomicrograph of *Aplanobacter Agropyri* from slide No. 111915; organisms from four-days-old sugar beet culture No. 111515, stained three minutes with carbol-fuchsin. Photograph made with B & L 1.9mm objective, Zeiss No. 2 projection ocular. × 1000 Original.

Fig. 2. *Bacillus subtilis* magnified × 1000; for comparison with figure 1. Original.

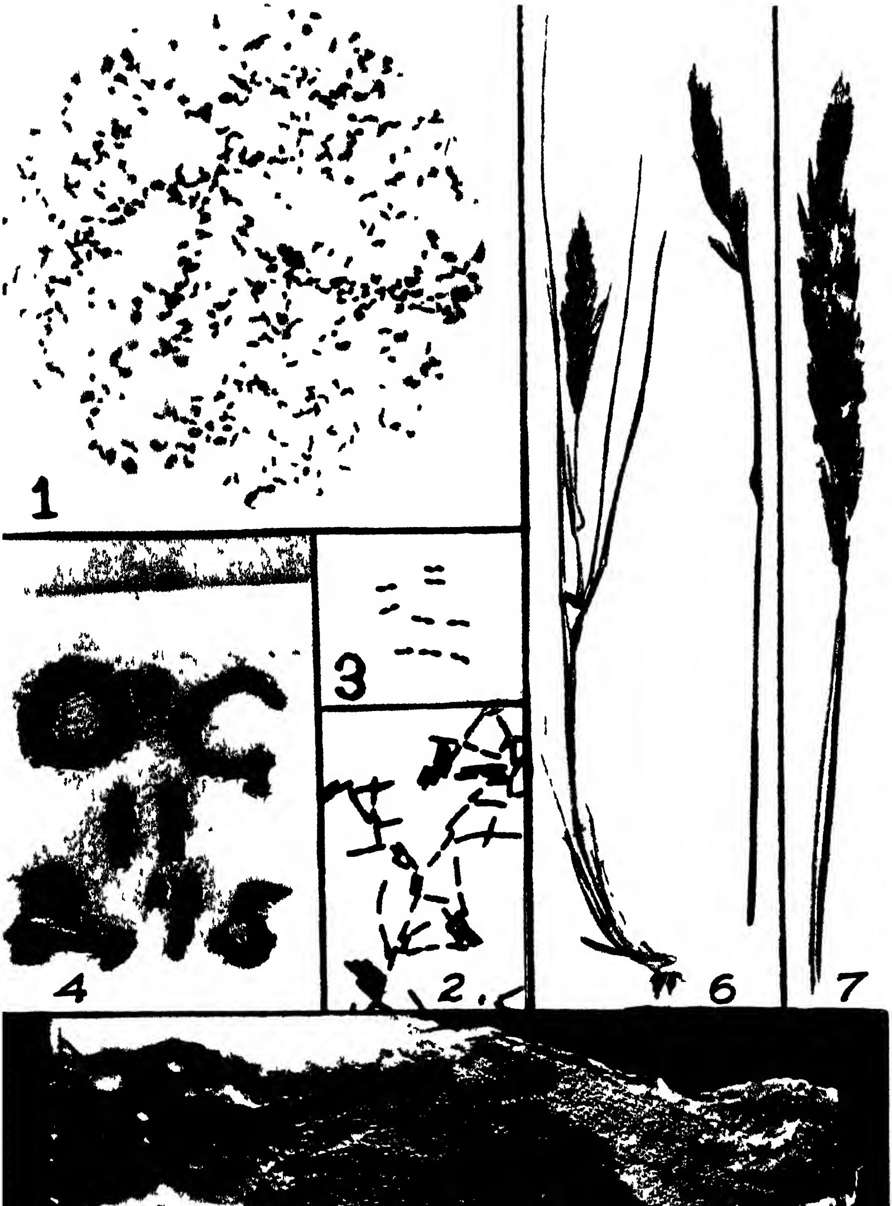
Fig. 3. *Aplanobacter Agropyri* showing capsules. Organism stained by Ribbert's method; from ten-days-old potato culture. (Original wash drawing.)

Fig. 4. Culture of *Aplanobacter Agropyri* on sugar beet slice No. 11215; culture ten days old when photograph was made. Natural size, showing raised character of bacterial growth. A platinum loop very nearly the width of the streaks was used in inoculating. This shows the non-spreading character of the organism. Original.

Fig. 5. Photograph of ten-days-old potato slant culture of *Aplanobacter Agropyri* showing the upper end of the slant. × 5. Note the shagreened appearance of the surface growth. Original.

Fig. 6. Specimens of *Agropyron Smithii* showing the peculiar bends in the stems produced by *Aplanobacter Agropyri*. Specimens collected near Murray, Salt Lake County, Utah, August 23, 1915. One-half natural size. Original.

Fig. 7. Photograph of inflorescence of *Agropyron Smithii* showing the bacterial ooze collected in droplets on the glumes. Specimen collected near Murray, Salt Lake County, Utah, August 23, 1915. Nearly natural size. Original.



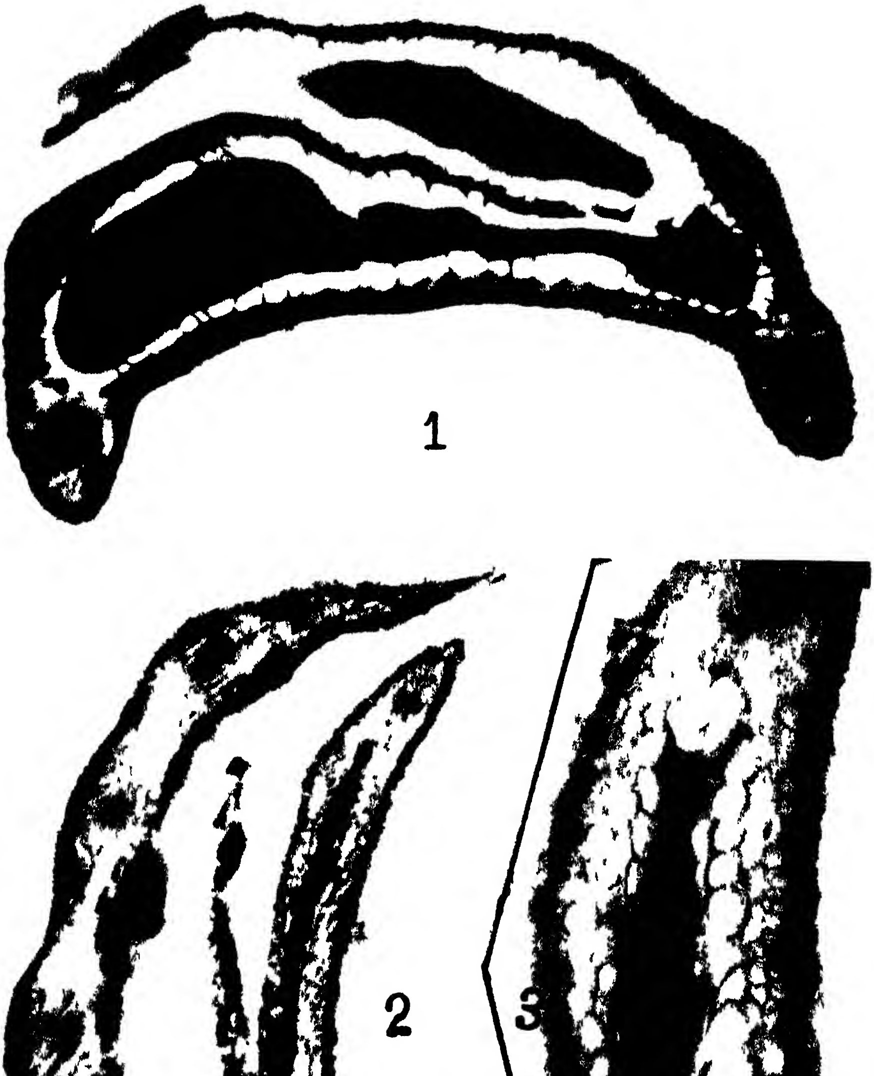
O'GARA APLANOBACTER AGROPYRI

Explanation of Plate XII

Fig. 1. Cross-section of upper one-third of diseased inner glume of *Agropyron Smithii* from material collected July 6, 1915, cut and mounted unstained September 1, 1915; photograph made with B. & L. 16 mm. objective, no. 2 Zeiss projection ocular, November 14, 1915 × 87. The amorphous masses between the cross-sections of the parts of the glume are composed of yellow, bacterial slime which has become hardened. In cutting the section the tissues were separated from the bacterial masses. Original.

Fig. 2. Cross-section of lower one-third of spikelet of *Agropyron Smithii*, from material collected July 6, 1915, cut and mounted without stain August 23, 1915: photograph made with B & L 16 mm. objective, Zeiss no. 2 projection ocular. November 14, 1915. × 100. The amorphous masses between the cross sections of the glumes are composed of hardened, yellow, bacterial slime. Original.

Fig. 3. Cross-section of inner glume of *Agropyron Smithii*, the part being selected from the lower one-third of glume as shown in figure 2; photograph made with 4 mm B. & L. objective, Zeiss no. 2 projection ocular, November 14, 1915. × 331 The black amorphous mass consists of hardened, yellow, bacterial slime. It is readily seen that the bacteria have not entered the cells or the intercellular structure of the glume Original.



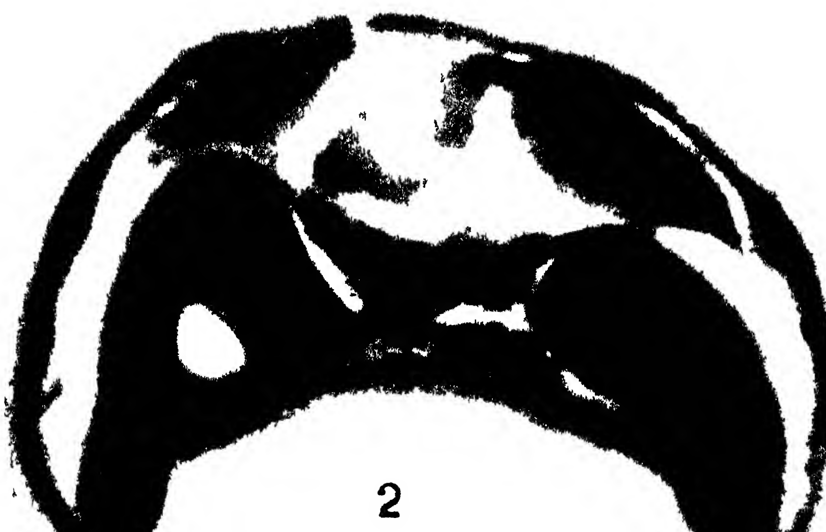
O'GARA: APLANOBACTER AGROPYRI

Explanation of Plate XIII

Fig. 1. Cross-section of upper one-third of normal spikelet of *Agropyron Smithii* showing the inner and outer glumes together with the three anthers in cross section. The pollen grains can readily be made out. From material collected near Murray, Salt Lake County, Utah, July 6, 1915, cut and mounted without stain August 23, 1915. Photograph made November 14, 1915, with 16 mm. B. & L. objective, Zeiss no. 2 projection ocular × 78. Original

Fig. 2. Median cross section of spikelet of *Agropyron Smithii*, cut and mounted August 14, 1915, from material collected July 6, 1915, near Murray, Salt Lake County, Utah. Photograph made November 14, 1915, with 16 mm. B. & L. objective, Zeiss no. 2 projection ocular. ×78. The amorphous masses between the sections of the inner and outer glumes are composed of hardened, yellow, bacterial slime. Original.

1



2

O'GARA: APLANOBACTER AGROPYRI

THE OCCURRENCE OF BAMBOO SMUT IN AMERICA

FLORA W. PATTERSON AND VERA K. CHARLES

WITH ONE FIGURE IN THE TEXT

Among the plants of special interest and economic importance which have been introduced from abroad through the Office of Foreign Seed and Plant Introduction are the bamboos. The popular but erroneous conception regarding these plants is that they are largely tropical, mainly adapted for ornamental purposes, but not of particular utilitarian value. Many Japanese bamboo plants had been growing in the United States prior to the work of introduction by the Department, but the object of the latter was to secure and to establish the timber species and to interest a large class of cultivators in the regions suitable for the growing of bamboos. The Department has imported several species of bamboo, mainly members of the genus Phyllostachys, but the two of special interest in this paper and of economic importance as timber species are *P. henonis* Mitford (*P. puberula* Munro) and *P. quilioi* Rivière (*P. bambusoides* Sieb. and Zucc.). The introduction of any new plant is always a question of serious concern, not only because of the expense which the government agricultural explorer must incur, the difficulties and hardships to which he may be subjected, but also because of the possibility of the introduction of new plant diseases which may not only kill the new introduction but attack also the plants indigenous to this country or those already successfully established.

In March, 1910, the Office of Foreign Seed and Plant Introduction ordered consignments of *Phyllostachys henonis* to be sent from its field station located at Chico, California, to Brooksville, Florida, and to Avery Island, Louisiana. A diseased condition of the plants remaining at Chico was observed shortly after the shipments had been made and an order was immediately sent to the points of destination directing the plants not to be unloaded until further notice. At the same time specimens from Chico were forwarded to the Office of Pathological Collections and Inspection Work for the identification of a probable pathogenic organism. The trouble was promptly diagnosed as a fungous disease, caused by a species of Ustilago. Its serious nature was immediately recognized and in accordance with the advice given by this office, an order was issued by the Office of Foreign Seed and Plant Introduction to inspect carefully

FIG. 1. Diseased and normal stalks of *Phyllostachys henonis* affected by the bamboo smut, *Ustilago shiraiana* Henn.

all plants and to treat or burn any showing the slightest evidence of disease.

For many years it has been the regular policy of the Department of Agriculture to inspect all foreign importations received at Washington, but these plants had been imported from Nagasaki, Japan, through the port of San Francisco in February, 1909.

DISCUSSION OF THE FUNGUS

In 1900,[1] Dr. Paul Hennings described a smut on a wild Japanese bamboo, *Sasa ramosa*, which he named *Ustilago shiraiana*. In 1905,[2] Dr. Shorato Hori published an article on smut of the large cultivated bamboo in which he states that he had received a specimen of smutted *Phyllostachys puberula* from the province of Mino in 1894. This specimen had been retained in the herbarium of the station at Tokyo under the unpublished name of *Cintractia bambusae* Miyabe and Hori. Later Dr. Hori had an opportunity to examine additional diseased material not only of *P. puberula* (*P. henonis*) but also of *P. bambusoides* (*P. quilioi*), and also had an opportunity to observe the disease in several provinces of Japan. A careful study was made of the microscopic characters of the fungus and exact measurements were obtained of the spores on the different hosts. While this study caused Dr. Hori to make certain changes in the description of *U. shiraiana* Henn., he concluded that these smut fungi are identical and designated his species as *U. shiraiana* Hennings.

The fungus appears on the internodes and young growing parts of the branches as a deep brown, sooty mass. If examined microscopically, this mass is shown to consist of numerous spherical, subglobose or elliptical spores, light olivaceous to brown in color, with rather thin, smooth epispore and granular contents.

The following is the description of the fungus as emended by Dr. Hori:[3]

Produced on the growing points and internodes of the young branches causing often deformation or distortion; spore-masses at first covered by the leaf-sheath and bracts, pulverulent, deep brown; spores spherical, sometimes subglobose or elliptical, the rounded ones 6 to 10 μ in diameter, and the elongated ones 5.5 to 10 by 6 to 12 μ in size.

Epispore light olivaceous, smooth, contents finely granular with some oil globules; promycelium cylindrical or long fusiform, pedicellated, 1 to 2 septate, evanescent; sporidia terminal and lateral, long fusiform or elliptical, develop into the new promycelium.

[1] Hennings, P. Fungi japonici, I. Engler's Bot. Jahrbüch. **28**: 260. 1900.

[2] Hori, S. Smut on cultivated large bamboo (Phyllostachys). Bul. Imp. Cent. Agr. Exp. Sta. Japan, **1**: 73. 1905.

[3] Hori, S. Bul. Imp. Cent. Agr. Exp. Sta. Japan, **1**: 86. 1905.

SYMPTOMS OF THE DISEASE

According to Dr. Hori's investigations and observations of the writers the disease always occurs on the young and growing points of branches. When the young, short branches, still covered by the leaf-sheaths and bracts, are attacked they appear somewhat swollen but show no external discoloration. The growth of such diseased branches is arrested and finally, as the external covering of the buds falls away, the sooty portions are exposed. In cases in which most of the young branches are diseased, the winter buds or undeveloped spring buds begin to develop, and at a certain stage of the disease a hexenbesen or witches' broom formation is often apparent.

DISSEMINATION OF THE FUNGUS

Dr. Hori states that the wind is the principal factor in the dissemination of the disease and observes that the branches of bamboo growing on the outside of a grove are much more smutted than those farther in the forest. The important question which confronts the Department of Agriculture, in relation to the importation of bamboo or the distribution of bamboos already established in the United States, is whether the fungus may remain dormant in the rhizomes or stems for an indefinite period, making its appearance when conditions are favorable. The observation and experience of this office indicate that the fungus may remain dormant or at least may not produce the characteristic smutted appearance for some time. This inference is drawn from the fact that plants of *P. henonis* imported from Nagasaki, Japan, in February, 1909, did not show conspicuous spore formation until over a year later. *P. quilioi* was received from the same locality at the same time but no specimens were sent for identification until 1914. Of course, it is possible that the disease may have occurred prior to 1914, but if so, it was not sufficiently conspicuous to attract the attention of the plant introducers or propagators.

GEOGRAPHIC DISTRIBUTION

According to Dr. Hori,[4] smut has been found on several kinds of bamboo, both wild and cultivated, throughout the Empire of Japan. He states that it is known to occur on the four following species of bamboo: *Phyllostachys bambusoides* Sieb. & Zucc., *P. puberula* Munro, *Sasa ramosa* Makino and Shibata, and *Arundinaria simoni* Riv. var. *chino* Makino and Shibata.

[4] Hori, S. Bul. Imp. Cent. Agr. Exp. Sta. Japan, 1: 78. 1905.

In conversation it was learned from Mr. Frank N. Meyer, Agricultural Explorer for the Department of Agriculture, that he has observed the disease in China, especially in the province of Chekiang.

In America the disease has been observed on *P. henonis* and *P. quilioi* as already stated in this paper.

SEVERITY OF THE DISEASE

In Japan this disease is extremely serious and of greatest economic importance to the bamboo grower, as it may lead to the death of the entire forest.

In view of the seriousness of the disease the Department would urgently recommend that all bamboo growers watch their plants for any evidence of smut. When we consider that the monetary loss of small grains from smuts in the United States can be estimated at from twenty-eight to thirty-five millions of dollars annually, we appreciate the great importance of eradicating this disease before it has become established in our bamboo plantations. With this object in view steps have been taken to control the situation.[5] The presence of the fungus not being conspicuous in the early stages, it is well to scrutinize the young growth closely, opening the glumes and running the fingers along the internodes to discover whether the black, powdery spores of the smut are present. As a witches' broom formation is sometimes associated with this disease, the grower should watch for any such appearance and hold the plants so affected under careful observation.

CONTROL

Fungi of this class are exceedingly difficult to control, the method of treatment being prophylactic rather than palliative or curative. In the control of smuts on cereals, the seeds are frequently subjected to fungicidal treatment before planting and thus the chances of seed infection are obviated or in a large degree lessened. In bamboo, because of the perennial habit of the plants and the different method of propagation, this treatment is not practicable. Theoretically, breeding and selection of resistant varieties would appear to be the most promising method of controlling the disease. Burning all diseased plants is the only sure means of eradicating this fungus. Spraying with bordeaux mixture when the

[5] Realizing the potential seriousness of the smut disease of bamboo the Department prepared a circular letter of warning, containing a description and illustrations of the disease, and distributed copies to all those interested in bamboo culture in the United States. In this letter growers were requested to send any suspicious material to the Department for mycological identification and pathological advice.

spring buds begin to develop has been suggested as probably beneficial and may lessen the danger of reinfection but it cannot be regarded as a positive means of control.

Although our opportunity of studying the disease has been extremely limited and confined to laboratory investigations, we are inclined to believe that the mycelium may persist for a long time in the older stems and give rise to successive infections. This point, however, can be determined only by extensive field observations and microscopic studies.

OFFICE OF PATHOLOGICAL COLLECTIONS
BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

SPORE VARIATION IN NEOPECKIA COULTERI

J. S. Boyce

While examining some collections of *Neopeckia coulteri* (Pk.) Sacc., the writer found, in material collected by E. P. Meinecke on *Pinus monticola* near Grassy Lake, Shasta County, California, at an elevation of 7000 to 8000 feet on September 26, 1914, that certain of the spores had become two- and sometimes three-septate by the formation of a secondary septum in either one or both of the original spore halves.

In all, sixteen collections of *Neopeckia coulteri*, made by Meinecke and the writer in the Sierra Nevada and Siskiyou Mountains of California at elevations varying from 5800 to 11,500 feet, have been examined. Absolute identifications have been possible of five specimens on *Pinus contorta* (*murrayana*), three on *P. monticola*, two on *P. albicaulis* and one on *P. ponderosa*. This last-named host is new for the species. This latter collection was made by the writer near Hobart Mills, Sierra County, California, on September 28, 1914 at an elevation of 6300 feet. Only a few small saplings were found attacked by the fungus. In the remaining five collections, two on *Pinus jeffreyi*, two on *Pinus lambertiana* and one on *Pinus monticola*, no ascospores were found so it is assumed that the fungus is *Neopeckia coulteri*; a logical assumption, since our present knowledge is that the only fungus occurring on coniferous species in this country within the range of *Neopeckia coulteri* and closely resembling it is *Herpotrichia nigra* (Pk.) Sacc., never reported in North America on any species of Pinus while *Neopeckia coulteri* has never been reported on any host other than Pinus. However, material on *Pinus montana* from the Bavarian Alps (in E. P. Meinecke's herbarium, obtained through the courtesy of Dr. von Tubeuf, Munich), upon examination, was found to be *Herpotrichia nigra*.

In all the collections of Neopeckia, with the one exception, the spores were characteristically and invariably uniseptate. Nor can the writer find any reference in the literature on the subject to a variation in this respect. Sturgis[1] describes the spores as, "strictly uniseriate, 2-celled, and becoming very dark brown as they mature," and again (p. 157), "Spores obliquely uniseriate in the asci, blunt elliptical, at first pale brownish, later dark brown, 1-septate, constricted at the septum, 20-29

[1] Sturgis, W. C. Herpotrichia and Neopeckia on conifers. Phytopath. **3**: 156. 1913.

x 9.5–10.2 μ." Engler and Prantl[2] characterize the spores of the genus as "Sporen 2-zellig, braun," while Ellis and Everhart[3] write "Sporidia uniseriate, oblong elliptical, slightly narrowed at the ends, uniseptate and constricted, brown, 20–30 x 8–10 μ."

In all the spores examined from the first-mentioned material on *Pinus monticola*, one spore-half usually appears slightly narrower than the other. In those spores with one additional septum, the primary septum is very plain and is accompanied by the characteristic constriction of the spore. The additional septum divides the narrower of the original spore-halves transversely into two equal secondary cells, but there is no constriction or only a very slight one; in some instances, the secondary septum is rather faint. This secondary septum is invariably found in the narrower of the spore-halves. In those spores in which both spore-halves are divided by additional septa into two secondary cells each, the primary septum is plain, with the usual constriction, while the secondary septa vary in distinctness; the constriction is lacking or very slight. The three types of spores do not have any definite position in the ascus, as one-, two- and three-septate spores or combinations of these were found in various parts of the same ascus.

A count of 500 spores gave 433 (86.6%) uniseptate, 58 (11.6%) biseptate and 9 (1.8%) triseptate. The results of the spore measurements[4] are as follows:

Uniseptate spores—(63) 7–11 μ x 23–27 μ (8–10 x 22-25).

Biseptate spores —(30) 7–10 μ x 22–27 μ (8– 9 x 25–27).

Triseptate spores —(6) 8–10 μ x 23–27 μ (8– 9 x 23–25).

As can be seen, the difference in size between the three types of spores is trifling. With the increase in the number of septa there is no increase in width of the spores at all. There is no increase in length except, seemingly in the case of biseptate spores, due, no doubt, to the unavoidable variations that always enter into measurements of this kind. That there is no real increase in length is shown by measurements of individual, original spore-halves without and with a secondary septum. The measurements are:

Spore-halves without secondary septum—(25) 7–9 x 12–14 (8–9 x 12–13).

[2] Engler, A. und Prantl, K. Die Natürlichen Pflanzenfamilien, I Teil, 1 Abt., p. 396.

[3] Ellis, J. B. and Everhart, B M. The North American Pyrenomycetes, p. 147.

[4] Meinecke, E. P. Spore measurements. Science n. s., **42**: 430. 1915.

In the measurements of the uniseptate spores for example, (63) is the numerical basis, 7–11 x 23–27μ are the extremes of width and length, while (8–10 x 22–25μ) are the most frequent values of width and length.

Spore-halves with secondary septum—(25) 7–9 x 12–14 (8–9 x 12–13).

A hanging drop culture of the spores suspended in tap water was made on April 20, 1915. By May 5, 1915 the swollen spores had germinated vigorously. Slits, or rarely, irregular tears appeared in the exosporium of the uniseptate spores and through these openings the hyalin germ-tubes grew out. These narrow and short slits, revealing the hyalin spore-contents, stood out clearly against the dark brown exosporium. In each spore-cell from one to three slits were formed, each one of which might be occupied by a germ-tube, though as a rule there were more slits than germ-tubes.

In accordance with their numerical relationship to the uniseptate spores, only five biseptate spores were found in the culture. One of these had not germinated, one had sent out a germ-tube from a secondary cell, while in the other three a germ-tube appeared from each cell. The splitting of the exosporium was again in evidence. This faculty of germination characterizes the formation of secondary cells as a normal, not a pathological, process. None of the rare triseptate spores had germinated.

In all of the material examined, two triseptate spores were found with pronounced constrictions at each of the three septa, giving the spores, except for the dark brown color and slightly larger size, the appearance of those of *Herpotrichia nigra*. On the other side, Meinecke's collections contain a *Herpotrichia* sp., found on *Primula* sp., with the normal biseriate triseptate spores of *Herpotrichia nigra* but of very large size. Their dark brown color, however, remind one distinctly of *Neopeckia coulteri*. Weir[6] describes a new species of Herpotrichia (*Herpotrichia quinqueseptata*) with 5-septate spores occurring on *Picea engelmanni*.

The triseptate Neopeckia spores described above and the Herpotrichia spores from Primula represent intermediate forms between *Neopeckia coulteri* and *Herpotrichia nigra* suggesting a very close relationship of the two fungi, which macroscopically cannot be distinguished from each other.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY
SAN FRANCISCO, CALIFORNIA

[6] Weir, James, R. A new leaf and twig disease of Picea engelmanni. Jour. Agr. Research 4: 251–253. 1915.

KEITHIA THUJINA, THE CAUSE OF A SERIOUS LEAF DISEASE OF THE WESTERN RED CEDAR

JAMES R. WEIR

WITH TWO FIGURES IN THE TEXT

Observations in the lake region of northern Idaho during the field seasons from 1912 to 1915 show that *Keithia thujina* Durand[1] is the cause of a serious leaf disease of the western red cedar, *Thuja plicata* Don. This is important since the fungus has not been heretofore reported on this valuable timber tree, moreover it is the only fungus of economic importance so far found attacking the leaves of this species (fig. 1).[2]

Since the fungus is likely to become serious in forest nurseries and of considerable importance in the forest, its chief characteristics should be reviewed. The apothecia are embedded in the tissues of the scale-like leaves of the host and are exposed on maturity by the rupture of the epidermis as a flap or scale (fig. 2, *a*). The cushion-like apothecia depressed or elevated according to the humidity of the air are circular, elliptical, curved or irregular in outline and may occur three or more on a leaf (fig. 2, *b*). At first they are a rich olive-brown but become almost black with exposure. The ascus bears two highly characteristic spores which are at first hyaline, elliptical or pyriform in shape (fig. 2, *c*) but on reaching maturity become olive-brown and more circular in outline (fig. 2, *d*). The spores are further characterized by a pitted surface and by being divided into two very unequal cells by a transverse wall at the distal end (figs. 2, *d* and *e*). The paraphyses are septate, branched or single and broadly thickened at the ends (fig. 2, *d*).

Durand's surmise[3] that *Keithia thujina* "under favorable conditions or in certain seasons might become serious" is well founded. The leaves of trees of all age classes are attacked, the severity of the attack depending upon the humidity of the site. The lower branches of young trees from twenty to fifty years of age, when growing in dense stands on low ground, often appear at a distance as if scorched by fire. In October and No-

[1] Trans. Wis. Acad. Sci. Arts Let. **16**: 759. 1909. Mycologia **5**: 9–10. January, 1913.

[2] The writer is indebted to Dr. F. J. Seaver for the determination of the fungus. Material was also compared with collections made by Dr. J. J. Davis on *Thuja occidentalis* at Hickory, Wisconsin. (Fungi Columbiani 4030.)

[3] Mycologia **5**: 10. January, 1913.

vember the young infected leaf-twigs fall leaving the branches quite bare. On leaves remaining attached to older twigs, the presence of the fungus is readily determined by the fact that the apothecia fall out leaving a pit that almost perforates the leaf (fig. 2, *b*). These leaves turn an ashy gray contrasting with the reddish brown leaves which fall earlier in the year. Seedlings under four years of age are killed outright in a single season.

FIG. 1. Branch of *Thuja plicata* infected with *Keithia thujina*, natural size.

A plot of fifty square feet of heavy reproduction in open forest in the Kaniksu National Forest (Priest River Valley) containing four hundred and thirteen seedlings showed by actual count four hundred seedlings killed by this fungus, or about 97 per cent of the entire stand. Infections equally severe occur in many parts of the forest.

Keithia thujina is primarily a fungus of seedlings and young trees. The foliage of the upper crown of large forest trees may be very generally infected but never to the same extent as the leaves on branches near the ground. The fact that seedlings are usually severely infected indicates that snow may be a factor in promoting its growth. This is particularly noticeable where seedlings remain covered with snow until late in

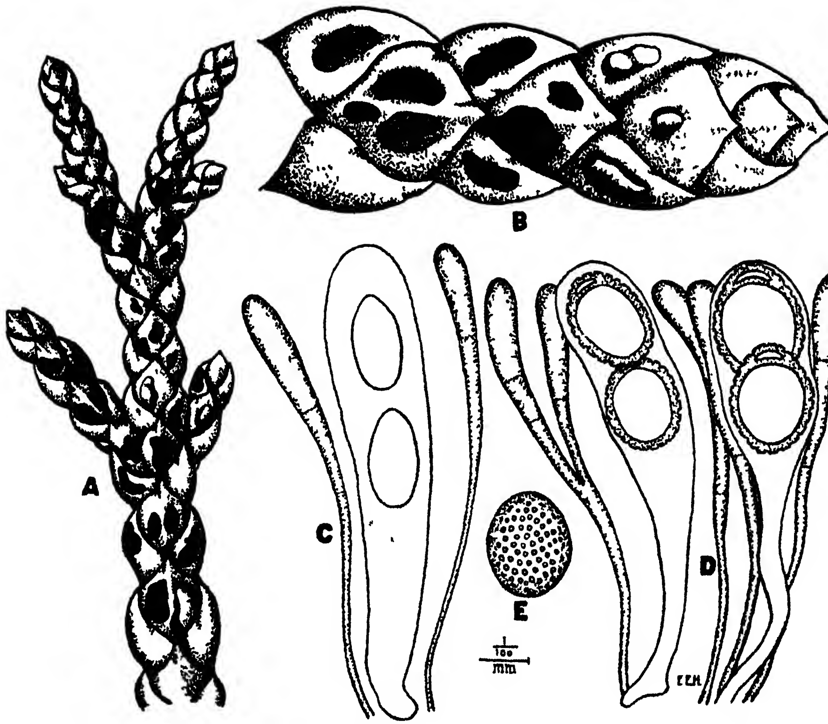


FIG 2 *A*, Branch of *Thuja plicata* infected with *Keithia thujina* showing forms of apothecia with epidermal scale. *B*, Leaves of *Thuja plicata* infected with *Keithia thujina* showing apothecia much enlarged with epidermal scale falling away, also pits in the leaf after the disappearance of the apothecia. *C*, Immature ascus and spores of *Keithia thujina*. *D*, Mature asci and spores of *Keithia thujina* showing the small cell at distal end of spore. *E*, Spore of *Keithia thujina* showing surface markings

the spring. The branches of young trees growing in deep ravines which are covered with snow for a long period of time are generally more severely attacked than those branches higher on the trunk. The fungus is at all times most abundant in regions of great atmospheric humidity.

Sporulation begins about the last part of June. By the middle of October the asci have discharged the most of their spores while the apo-

thecia are still attached to the leaves. Spores may be found in limited quantity in the apothecia after they have fallen from or together with the leaves. The hygroscopic nature of the substance of the apothecium which causes it to swell out like a cushion during wet weather is a factor in spore liberation. This also initiates the formation of the fissure around the apothecium resulting in its fall from the leaf.

Keithia thujina is widely distributed throughout the range of its host, having been found from southern British Columbia to central Oregon and eastward to the Bitter Root Mountains in Montana.

The fact that the spores of *Keithia thujina* are principally disseminated during the autumn months while the infected leaves are still attached led to the following preliminary experiment. On August 3, 1914, six seedlings ranging in height from four to six inches were taken up in a part of the Priest River region where the fungus has not yet appeared and transplanted into the midst of a heavy reproduction of cedar (Thuja) of about the same size and which was severely infected with the fungus. The six seedlings remained thrifty after transplanting. From the time of transplanting and extending into October, three of the seedlings were heavily treated with the stronger soap-bordeaux solution at intervals of ten days or oftener during rainy weather. When examined on April 5, 1915, one of the sprayed seedlings showed four infections on as many leaves. The other two were entirely free from the disease. The three seedlings which were not treated were as severely infected as those of the original stand. This result, though based on a single experiment, indicates that the disease may possibly be controlled in nurseries, if at any time it is found necessary, by using the above well-known remedy.

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TWO INTERESTING DISEASES OF GREENHOUSE TOMATOES

Mel T. Cook and C. A. Schwarze

With One Figure in the Text

During the spring of 1915 two very interesting fungous diseases of tomatoes appeared in the greenhouses of the New Jersey Agricultural Experiment Station. One fungus occurred as a leaf parasite, while the other confined its activities to the fruits.

The lesions of the leaf parasite first appeared as small, brown, circular spots which gradually became larger and grayish brown in color. These spots were marked with delicate, black, more or less irregular concentric circles and were somewhat similar in appearance to the spots of the early blight caused by *Macrosporium Solani* E. & M. An examination of the spot with the hand lens revealed many small, black pustules. After a few hours in the moist chamber, great numbers of whitish spores were exuded in strings from these pustules.

The fungus corresponds with *Ascochyta Lycopersici* Brun., which is recorded in Saccardo's *Sylloge Fungorum* (**10:** 304) as occurring on the leaves of weak tomato plants in Italy and France, except that our organism occurs on both old and new leaves of strong plants and also on vigorous young plants. The pycnidia are usually globose, sometimes ellipsoid or irregular. The spores are hyaline, one-septate, slightly constricted at the septum and 7.5 to 9 by 2.5 μ.

In culture the organism produced an abundant growth of mycelium on several different media and also pycnidia without spores. The mycelium is whitish becoming black with age. Puncture inoculations, made with the mycelium from cultures, on the leaves and green fruits of healthy, vigorous plants produced typical spots in a few days.

The disease cannot be considered of very great importance. It was most severe on the magnus and the yellow and red plum varieties.

The fruit rot lesion started at the blossom-end of ripe and half ripe fruit, gradually spreading and exhibiting symptoms practically the same as those usually described for the blossom-end- or point-rot. The surface of the rotten area very soon became covered with a dense grayish brown powdery mass which proved to be a species of Botrytis.

The fungus was isolated in cultures and made luxuriant growths on tomato plugs, potato agar and Cook's No. II, producing large, black

sclerotia. The spores are egg-shaped, smoke colored and 7.5 to 10 by 6 to 7 μ.

The disease was most common on fruits with roughened blossom-ends. Under the quiet conditions of the greenhouse, the dead blossoms frequently cling to the blossom-ends of the fruits. Under the moist conditions of the greenhouse, these dead blossoms present especially favorable conditions for the growth of the fungus which penetrates the fruit through the roughened surface and causes the typical blossom-end-rot. Examination of these dead blossoms found clinging to the fruits and also on the ground, showed them to be always filled with the Botrytis.

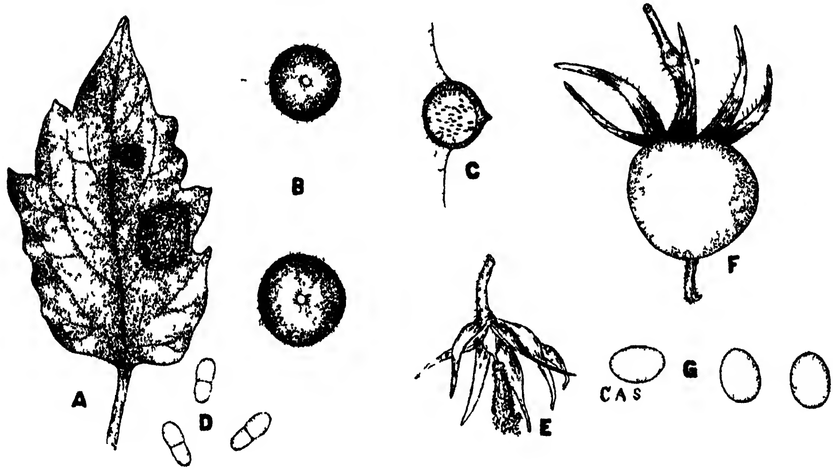

FIG. 1 *A*, Leaf of tomato showing spots produced by *Ascochyta Lycopersici*. $\frac{3}{4}$ natural size. *B*, Pycnidia of *A. Lycopersici*. *C*, Section of pycnidium of *A. Lycopersici*. *D*, Spores of *A. Lycopersici*. *E* and *F*, Dead corolla attacked by Botrytis clinging to young fruit. *G*, Spores of *Botrytis* sp.

When the spores from pure cultures were applied to the roughened blossom-ends of fruits and the fruits kept under moist conditions, the typical rot was produced. When smooth tomato fruits were treated in the same manner, no rot was produced. When smooth fruits were punctured with a sterilized needle and subjected to the same treatment, the typical rot was produced.

These two diseases, the one having symptoms similar to the early blight of the tomato and potato, and the latter producing symptoms practically the same as the well-known blossom-end-rot, serve to demonstrate the fact that symptoms are not always reliable for diagnostic purposes. Many of the apparently contradictory statements in our literature are no doubt

due to this cause. It is also very probable that many minor causes of diseases have been overlooked because producing symptoms similar to those associated with common and well-known diseases.

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PHYTOPATHOLOGICAL NOTES

A convenient, little-known method of making micro-mounts of fungi. The outline here given is a modified method of Winter. It has proved so useful and appears to be so little known that it seems worth while to direct attention to it.

As described by Gaillard in *Le Genere Meliola*, 1892, p. 13, the procedure is as follows: a drop of celloidin solution is placed on the fungus, allowed to dry, then lifted off, bearing the fungus with it. He recommends celloidin solution of the following composition:

Celloidin	4 g.
Alcohol	10 g.
Ether	32 g.
Castor oil	2 g.
Lactic acid	2 g.

He lifts the celloidin film with forceps to a slide then dissolves the celloidin in ether-alcohol.

Alcohol	10 g.
Ether	32 g.

The fungus is then mounted in glycerine jelly. In my personal experience, involving nearly 10,000 mounts, mostly species of Meliola, I have modified the formula by omitting the oil and acid. As soon as the edges curl I find it entirely practicable to lift the celloidin film to a slide, then dehydrate by flushing a few times, usually only twice, with absolute alcohol, then with xylol, after which the mount can be made permanent in xylol-balsam. This procedure eliminates dissolving celloidin film, as recommended by Gaillard, and leaves the fungus permanently encased in the celloidin, which so far as I have been able to observe is no disadvantage.

With all superficial fungi which need no staining the above method serves. It is particularly useful with Meliola, the Microthyriaceae, Perisporiaceae, Torulas, Capnodiums, and so forth, also for the study of natural spore grouping of such objects as the rusts, Moniliales, and so forth.

Good mounts may also be made of the powdery mildews, vastly better mounts than are secured by the usual methods; but still better preparations may be made by applying some suitable stain, as bismarck brown

or gentian violet, to the fungus upon the leaf, washing off superfluous stain, dehydrating, then proceeding as above.

The method also has been found serviceable for the study of colonies on agar. Here it is best to let the medium become dry, then proceed as above, but when occasion demands, colonies can be lifted from the moist agar; in such event, however, extra precaution must be observed in dehydration.

Accidentally I have frequently included superficial algae, liverworts, and even mosses. Such excellent mounts have been secured as to indicate the utility of the method for these groups also.

In practice I have a dropping bottle of 4 per cent celloidin on my table. Drops may be placed rapidly on a number of colonies, and in about five minutes the films are ready to transfer to slides. Alcohol and xylol are successively applied from dropping bottles. Any cloudiness, of course, indicates imperfect dehydration or water from some source. In this way it is possible to make in a very short time a large number of wonderfully good permanent preparations, which preserve the natural position of all parts of the fungus, spores on their conidiophores or mycelium, in natural order.

F. L. STEVENS

A root disease of prunes. During the summer of 1915, a peculiar prune disease appeared in the western part of the Snake River valley in Idaho. In the early part of the season the trees were apparently normal; they blossomed and set fruit, and had produced from six to ten inches of new growth, when they suddenly wilted and died. The final collapse usually came so rapidly that both leaves and fruit remained clinging to the branches. In some cases dying proceeded more slowly and was characterized by dropping of the fruit and by yellowing and dropping of the leaves.

Examinations of the roots of trees which had died rapidly showed that the entire root systems were dead; while examinations of roots from trees which had died more slowly showed that their root systems were not entirely destroyed. A study of those which were partly dead indicated plainly that death had proceeded from the ends of the roots toward the crowns and was not due to the action of parasites. The sap from diseased trees had a peculiar, sour odor, from which the local name "sour sap" was probably derived.

An investigation of a large number of prune orchards brought out the fact that two- and three-years-old trees seldom died of this disease. These trees, having had a small amount of leaf surface during the previous year, did not draw heavily upon soil moisture, so sufficient moisture was left

to keep them alive during the winter. Most of the three-years-old trees that died had been grown in orchards that had been intercropped during the previous season, and had therefore shared the soil moisture with other plants.

By far the largest number of trees which died were four years old. Having been more plentifully supplied with foliage these trees had drawn more heavily upon soil moisture. Cultivation had been valuable in conserving such moisture as was in the soil, but it had also killed the surface roots. The trees, therefore, could not take advantage of light rains or irrigations that did not penetrate deeply. Older trees which were not cultivated did not suffer so severely.

Most orchards showing this type of injury had received an insufficient supply of water during the preceding fall. The winter was cold and open, permitting a large loss of soil moisture. The light showers which fell early in the spring moistened the surface soil and probably helped to save the older trees which had not been cultivated and whose roots came near the surface. Where the cultivation had been deep, the rain could not penetrate to a depth where it could be reached by the roots.

That orchard which had by far the highest percentage of "sour sap" was on well-drained soil. It had been deeply cultivated and had received no irrigation whatever during the previous year.

Although most of the prune trees in the orchards studied were purchased as "peach grafted," water sprouts from these stocks indicate that they differ greatly. It is quite possible that differences in the resistance of these stocks to drought account for the occasional tree which has survived while trees about it have succumbed.

It was quite evident that the lack of moisture during the preceding fall and winter had caused the smaller roots to dry out and die. In the spring when the water was turned on and stored food became available, the bud began to swell, blossoms were produced, fruit set, and the leaves unfolded. The added leaf surface, the formation of fruit, and the increasing dryness of the air, made increasing demands for water, which the dead and decaying roots were unable to supply, and death resulted.

MINA A. WILLIS

Preliminary note on the occurrence of Peridermium balsameum in Washington. During the summer of 1914, while working with the Forest Service in the Cascade Mountains (in the vicinity of Darrington, Snohomish County), the writer's attention was attracted by a white rust on the lower surfaces of the needles of white fir (*Abies amablis*) seedlings. Specimens were collected, but on account of lack of facilities were ruined.

The following summer the same locality was visited and the rust again

found. Samples were sent to Prof. J. C. Arthur, who was kind enough to identify it. It was provisionally referred to *Peridermium pseudo-balsameum* (D. and H.) Arth., but owing to the immaturity of the material and the consequent absence of spores, it could not be identified with any great degree of certainty.

In September of the same year (1915), while in the foothills of the Olympic Mountains (in the vicinity of Port Angeles, Clallam County), the rust was found very abundantly on the seedlings of grand fir (*Abies*

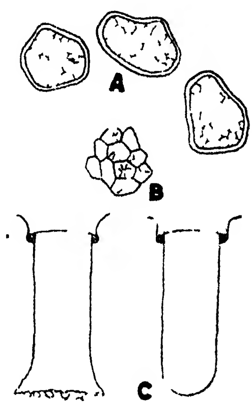

FIG. 1. Needles of *Abies grandis* infected with *Peridermium balsameum* Peck. The aecid a are evident on the lower surface of the leaves

FIG. 2. *A*, Spores of *Peridermium balsameum* Peck; *B*, A portion of the aecidium wall showing the cellular appearance; *C*, An open and closed aecidium.

grandis). Some of this material was also sent to Professor Arthur. The specimens were older and contained abundant spores. It was identified as *Peridermium balsameum* Peck.[1] The former samples were also referred to this species.

The rust has also since been found by E. J. Hanzlick in approximately the central portion of Mason County, making it extensively distributed throughout western Washington.

The white, elongated aecia are found on the lower surfaces of the needles, as shown in figure 1. Whether the affected leaves are deciduous

[1] Arthur, J. C., and Kern, F. D. North American species of Peridermium. Bul. Torr Bot. Club **33**: 403–438. 30 Au 1906.

or not could not be ascertained. The injury is not very evident, yet when a seedling is badly infected, as were a great many in the Port Angeles region, the leaves have a pale yellow appearance, especially immediately above the fruiting bodies.

The spores are more or less irregular in shape (fig. 2, a), measuring 19.2 to 21.6 by 24 to 28 μ. The cups open at the free end, giving the appearance shown in figure 2, c. The wall of the cup has a decided cellular structure (fig. 2, b).

The difference between *Peridermium pseudo-balsameum* and *Peridermium balsameum* is but slight, the only difference being that the former has slightly larger and thicker-walled spores. Both species are supposed to be alternate forms of rusts on ferns.

This is the first record of *Peridermium balsameum* west of the Mississippi Valley. Its abundance and perhaps economic bearing on various species of Abies makes it of particular interest.

HENRY SCHMITZ

The wintering of Coleosporium solidaginis. Ever since it was noticed that *Puccinia graminis* was wide-spread in countries where there was no barberry, attempts have been made to explain how such heteroecious rusts wintered when one or the other of the alternate hosts was absent. Besides the grain rusts, a number of heteroecious rusts are found in regions where their alternate host is not present. *Coleosporium solidaginis* (Schw.) Thüm. is such a one. This rust is found in its uredo- and teleutospore stages on species of Aster and Solidago and is distributed throughout the United States and Canada. *Peridermium acicolum* Under. & Earle, the aecidial stage, according to Arthur is found upon *Pinus rigida* in Connecticut, Massachusetts, New Jersey, and New York. Orton and Adams, besides finding it upon *Pinus rigida* in Pennsylvania, also report it upon *Pinus pungens.* Hedgcock and Wier and Hubert have recently shown that *Peridermium montanum* Arth. & Kern upon *Pinus contorta* in the West will produce this rust upon Solidago and is in consequence synonymous with *Peridermium acicolum.* The aecidial stage of the rust is thus limited in the eastern states to *Pinus rigida* and *Pinus pungens* and in the western states to *Pinus contorta.* The regions where these aecidial hosts are not found still have the rust on Aster and Solidago in great abundance.

On February 13, 1915, while on a collecting trip, my attention was called to a rust on *Solidago* sp. by Mr. Alfred Povah. This proved to be *Coleosporium solidaginis.* The unopen pustules of the rust were scattered over the rosette leaves of the Solidago, which was growing in a low, marshy place. The spores from these pustules did not germinate

when placed in distilled water. On February 27, a few open pustules were obtained from some of these plants, and these gave a fair germination in distilled water. On April 17, pustules were found upon the rosette leaves of a Solidago in a similar marshy place in another locality. On May 6, open pustules were found upon the rosette leaves, and unopen pustules were present on the leaves of the stem, which had been formed by this time.

On January 4 of the present year (1916), infected rosettes of a Solidago were again found in a marshy locality. The spores from the pustules on the leaves of these plants gave no germination in distilled water. On January 8, a few open pustules were found and these had spores which gave a fair germination in distilled water. On January 21, three plants with pustules upon some of the leaves of the rosette were brought in and the infected leaves were cut off. Pustules appeared upon the other rosette leaves from day to day and as fast as these appeared the leaf was cut off. By February 11, the wintered rosette leaves were all cut off. The new leaves which developed did not produce pustules at this time or later. At this time other infected plants were brought in and free-hand sections were made of the different parts of the plant. These were treated with chloral hydrate and iodine to make the mycelium stand out. Mycelium was found only in the rosette leaves and in these only in limited areas.

From this it appears the *Coleosporium solidaginis* winters in the rosette leaves of *Solidago* sp., both as mycelium and as uredospores, and that in regions where the alternate host is not found the uredospores formed from this wintered mycelium will serve as the source of infection in the spring.

E. B. MAINS

Successful inoculations of Larix occidentalis and Larix europea with Melampsora bigelowii. Collections of leaves of *Salix bebbiana* Sarg. bearing telial sori of *Melampsora bigelowii* Thüm. were made in Pattee Canyon near Missoula, Montana, on March 12, 1916. On April 15, 1916, freshly germinating teliosporic material of *Melamspora bigelowii* was sown on one seedling of *Larix occidentalis* Nutt. in the greenhouse at Missoula. Pycnia appeared on May 2 and aecia on May 5, resulting in a heavy infection of all the young needles subjected to the inoculation. Control plants remained normal.

On April 18, 1916, an inoculation of two seedlings of *Larix europea* was made with teliospores of *M. bigelowii* on *Salix cordata mackenzieana* Hook., collected at Priest River, Idaho, April 13, 1916. Pycnia appeared on May 5 and aecia on May 8, giving a medium infection of those needles subjected to the inoculation. The aecial stage developing on the two

larches was found upon examination to be identical. All inoculations were isolated by the use of celluloid cylinders and cotton plugs at the greenhouse of the Office of Investigations in Forest Pathology, Department of Agriculture, at Missoula, Montana. Control plants remained normal.

JAMES R. WEIR
ERNEST E. HUBERT

A successful inoculation of Abies lasiocarpa with Pucciniastrum pustulatum. A collection of over-wintered leaves of *Epilobium angustifolium* L. infected with *Pucciniastrum pustulatum* (Pers.) Diet. was made on April 13, 1916, at Priest River, Idaho. The leaves were kept in a moist chamber for three days in the greenhouse at Missoula, Montana, and then suspended over young needles of one small tree of *Abies lasiocarpa* (Hook) Nutt. The inoculation was isolated by means of a celluloid cylinder and cotton plugs. The needles and inoculating material were kept moist by water sprayed with an atomizer. On May 14, several pycnia appeared on the younger needles at the tips of the branches, and on May 17 almost all the young needles bore a large number of aecia. Control plants remained normal.

JAMES R. WEIR
ERNEST E. HUBERT

Errata. The attention of workers with the Fusaria is directed to the following important errors in a memoir[1] on Fusaria of potatoes.

Page 92, omit the word *diffusum* and move page reference to species *effusum*.

Page 162, seventh line, and page 163, eighth line, for 3.7 read 1.7.

Page 166, next to last line, for *diffusum* read *effusum*.

Page 180, second line, should read: *F. arthrosporioides*, Ireland.

Pages 214 and 216, first word of the description, for *microconidia* read *macroconidia*.

C. D. SHERBAKOFF

Personals. Dr. Arthur Harmount Graves, formerly assistant professor of botany in the Sheffield Scientific School of Yale University and instructor in forest botany in the Yale Forest School, has been appointed associate professor of biology in the new Connecticut College for Women, at New London, Connecticut. Doctor Graves will have charge of the instruction in botany.

[1] Sherbakoff, C. D. Fusaria of Potatoes. Cornell Univ. Agr. Exp. Sta. Mem. 6: 85–270, 51 fig., 7 col. pl. 1915.

Dr. G. L. Peltier, formerly associate plant pathologist of the Illinois Agricultural Experiment Station, has accepted the position of pathologist of the Alabama Experiment Station.

Mr. J. R. Winston, formerly plant pathologist of the Hood River branch station of the Oregon Experiment Station, has been appointed assistant pathologist in fruit disease investigations, Department of Agriculture. He will assist Dr. H. R. Fulton in his investigations of the diseases of subtropical fruits.

Mr. Fred C. Meier, a student in the Laboratory of Cryptogamic Botany of Harvard University, has been appointed an agent of the Department of Agriculture for a temporary period of three months, beginning June 1, and will be engaged in the investigation of diseases of watermelons.

Recent appointments to the Office of Investigations in Forest Pathology, Department of Agriculture, are as follows: Samuel B. Detwiler, formerly field superintendent of the Pennsylvania Chestnut Tree Blight Commission, has been appointed forest inspector in charge of field work on the white pine blister rust.

Reginald H. Colley, lately assistant professor of botany in Dartmouth College, and Minnie W. Taylor, lately assistant in botany, in Brown University, have been appointed agents to assist Dr. Perley Spaulding in research on the white pine blister rust.

Paul V. Siggers, lately a graduate student in botany in the University of Michigan, and Gilbert T. Posey, research assistant in botany at the Oregon Experiment Station, have been appointed scientific assistants to Mr. Detwiler.

George L. Barrus and Norton M. Goodyear, recently engaged in commercial forestry, have been appointed agents also assisting Mr. Detwiler.

In addition to these more or less permanent appointments, about forty field agents have been appointed for temporary periods to work on the white pine blister rust in cooperation with various state officials. Field work on the white pine blister rust east of Ohio is organized under the general direction of Mr. Detwiler; west of and including Ohio, under the general direction of Mr. Roy G. Pierce.

LITERATURE ON AMERICAN PLANT DISEASES[1]

Compiled by Miss E. R. Oberly, Librarian, Bureau of Plant Industry

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[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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PHYTOPATHOLOGY

VOLUME VI NUMBER 5

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PHYTOPATHOLOGICAL WORK IN THE TROPICS

John R. Johnston

No one who has attempted phytopathological work in the Tropics will object to the statement that there are serious problems in those countries, but as, at the same time, someone may claim that in temperate climates also this subject presents some problems, it will be well to justify with rather full explanations special interest in the problems of the warm climates.

Tropical America is a most heterogeneous assemblage of countries, many of which are widely separated from one another, and have poor and slow means of communication To illustrate this, the Cuban Experiment Station is two full days from the nearest experiment station at Gainesville, Florida and three days from Washington. It is three days from the nearest station to the south at Kingston, Jamaica, and owing to quarantine troubles six days are often required to make the trip. To the east there is nothing in Santo Domingo nor Haiti, and it is five days to Porto Rico. From Cuba to Trinidad is more or less a matter of two weeks—and one would be fortunate to make it in that time.

The central American countries are about as close together as they can be arranged and so is northern South America, but to travel from part of one country to part of another may be a matter of weeks. Modern travel facilities have not yet penetrated all parts of tropical America.

This isolation of pathologists in the Tropics makes correspondence slow and almost prevents personal visits. Association with co-workers from adjacent countries including those in the north becomes an annual event, at least if one is fortunate. This isolation is bad for the pathologist and bad for the work.

There are not many pathological laboratories in the Tropics; they may easily be enumerated: in Surinam, Demerara, Trinidad, Barbados, Porto Rico (2), Jamaica, Cuba (1 private), Costa Rica (private), and in Mexico; this last being practically out of commission at present.

The equipment of these laboratories deteriorates faster than in the North, owing to the moister climate. Few of the present laboratories that have ever succeeded in obtaining good equipment have been able to get it replaced. Specimens to be of any value must be kept in dry, insect-proof cases, which are scarce in the Tropics. In wooden cases the white ants play havoc, and molds render confusion among specimens.

Buildings in the Tropics cannot be closed as in the North, so that it is impossible to keep out many insects, birds and bats. In one of the best furnished laboratories in the Tropics there is a constant fight against big cockroaches and rats. The writer has had rats remove cotton plugs from flask and tube cultures for the purpose of building nests. One well-known laboratory harbors great numbers of nesting swallows, apparently innumerable bats, rats, white ants and silverfish, so that the daily sweepings in this place usually fill several buckets.

So far as literature is concerned for reference to pathological work, the most useful collections that the writer has seen in these countries were the private property of the pathological workers. Sets of Saccardo's *Sylloge Fungorum* are seldom to be found in the laboratories. There is none at either of the two Stations in Porto Rico and none in Cuba. As a consequence, very little taxonomic work is done in the Tropics. The British men send their material to England and the Americans to the States. Occasionally determinations can be obtained in a few weeks, and just as often from four to six years are required.

Even with these conditions, good work is possible in the Tropics, as is shown by some of the publications, but it is a difficult task.

These conditions are accentuated by the restrictions of work to single countries. It is rarely the case that a tropical pathologist studies a disease outside his own country. He is employed by one government to study disease and naturally he is not supposed to be wandering off to the domains of another. It is not considered that many fungi do not appear constantly in the same place. Work on one fungus may be begun and then owing to seasonal changes may have to stop until the next year, or just as likely until the fungus appears the second year afterwards. Again reports may come that certain diseases do not exist in the country, and the following season a fungous parasite may develop as though it were an old resident.

This same variation in the development may cause a pathologist to report a fungus as a harmless, weak parasite, while in an adjacent country apparently the same fungus is damaging the crops and it may as likely as not turn out that the man in the former country will have to change his mind the second season.

As a consequence of this restriction of pathological activities and varia-

tions in conditions, we see pathologists in different countries working on much the same thing and apparently obtaining different results. Several pathologists have investigated the Panama disease of bananas and many years have been spent on it; much work has been done on a similar disease in Surinam, in Trinidad, in Porto Rico, in Jamaica, in Cuba, and by Washington workers also. Still the question is unsettled and different opinions are held as to the cause of the disease. The coconut diseases have served as a bone of contention for many years and the diseases of sugar cane have furnished us with much contradictory literature. The cacao diseases have received attention in various colonies, but there is no unanimity of opinion as to their cause.

The immense duplication of work is desirable—but only theoretically. It is desirable in the States, but not here—at least not to such an extent. As it exists at present, it is an enormous waster of energy, time, and money for the individual pathologist and for the government employing him.

Without exception, it appears to have been true that each one of the twelve or more men who have studied the Panama banana disease in the American Tropics has had to spend time getting acquainted with various phases of the disease and with the crop, and has performed similar preliminary experiments, and not one of them has been in a position to work to a satisfactory conclusion.

Pathological work in the Tropics is often spasmodic, erratic, and temporary; in Demerara little work has been done in phytopathology; in Barbados a great deal of good work has been done in spite of the fact that the pathologists have seldom been able to devote much time to it; in Trinidad much good work has been done by the present mycologist who has probably remained in his position longer than any other pathologist in the Tropics; in Porto Rico some good work has been done in spite of the changes; and in Jamaica and Cuba there has been good work. Withal, sometime we may expect to see some of the more serious diseases relegated to the painful memories of the past, but accomplishments will be at a great cost and with a great waste.

This utterly fails to give a conception of what might have been done under other circumstances with the same men. Most of the men have had short careers in any one position, a condition that has often resulted well for the men, but very poorly for the work. A period of one or two years is of some service in making disease surveys, but it is often of little value in solving strictly pathological problems. Some inoculation experiments and most control experiments require from four to six years for satisfactory results. And when control means securing disease-resistant varieties, ten years is a short time. Needless to say the term "disease-

resistant varieties" is more a figure of speech than a reality in the Tropics.

There are various reasons for the constant passing of pathologists in the Tropics. Perhaps it is sufficient to say that they change because they secure better positions. That a change is made in pathologists at any Station is a more serious proposition in the Tropics than in the North. The work of one or more years is left uncompleted, notes are lost, the new man must acclimatize himself, must learn the people (whether English-speaking or not), must learn the language, learn new crops and new diseases. Many times investigations that were begun are dropped, and others are taken up by the new man only to be left uncompleted when he goes. In other words, there are few people in the Tropics, in any position to assume authority, who have any permanent interest in problems which the Agricultural Stations are supposed to be solving.

Experiments have shown that rigid exclusion of diseased plants from disease-free territory is a practical proposition. Thus in the case of the banana disease or coconut disease let us prevent it spreading into territory where the disease does not occur. Let us go further and destroy what disease we have, and prevent the introduction of more. Thus we can now safely grow crops where before it was a difficult or impossible thing.

On many of the English islands the administration has been far-sighted enough to provide for plant inspection service. In Jamaica the banana disease, among others, is declared infectious and subject to treatment according to law. Any diseased plants found by the inspectors or anyone else are reported and destroyed, so that the disease may not be transmitted to other properties. In Jamaica and Trinidad it is the business of these inspectors to attend to such matters. In most other places diseases come and go without hindrance, great havoc results and the planter looks on helpless to prevent.

An inspection service does not exist in Santo Domingo, Haiti, Porto Rico, none of the Central American countries, nor the countries of northern South America. In Cuba at present there are districts free from the coconut budrot and from the banana disease. So far as the planters are concerned, it may happen any time that these disease-free areas may become infected. In parts of Honduras and the rest of Central America, the banana disease is progressing with the development of the industry.

Not only plant inspection in the individual countries is lacking, but quarantine laws also are wanting. There are, to be sure, such laws in some of the countries, but in many of them they are not enforced intelligently. Some countries are fairly strict on shipments to the United States because they are required to be if they wish to continue the trade. At the same time they are almost absolutely indifferent as to what comes

into their own country. They fail to see that unless they succeed in keeping out disease and pests from their own country, the day may come when they will have little to ship to the States.

These then are some of the problems in the phytopathological work in the Tropics; there is a great lack of communication, laboratories are poorly equipped and isolated from centers of information, the investigations have little permanence, there is a great deal of unnecessary duplication of work, there is a great lack of knowledge of varieties of plants to serve as a basis for certain work, there is a lack of plant inspection work, there is a lack of efficiently executed quarantine laws.

Conditions along these lines have improved during the last ten years and are still improving. In order that there should be less waste and that improvements should proceed more rapidly, it is suggested that a central office or bureau be formed, either in connection with some existing institution or entirely independently. Such a bureau should be supported by subscription from those countries interested. It might well have several lines of work, but along phytopathological lines they could well attend to such things as the following:

1. Keep records of all the work that has been done and is being done at all the various Stations.

2. Keep records of all economic plant parasites that occur in Tropical America.

3. In cooperation with, or independent of, local Stations perform lengthy investigations or experiments, as for example, a study of banana varieties and coconut varieties.

4. Make a disease survey of Tropical America.

5. Keep a record of all quarantine and plant inspection laws of the various countries of the Tropics.

6. Publish reports containing (a), miscellaneous mycological and pathological notes; (b), any information along quarantine lines.

To explain these aims more fully, it may be said that the prime purpose of keeping records of the work at the Stations is to prevent the loss of data consequent upon the removal or change of pathologists at Stations.

The object of keeping records of all economic plant parasites is to assist in the knowledge of the distribution of plant diseases and to furnish data for plant quarantine work.

To perform lengthy investigations has a two-fold purpose: first, to eliminate unnecessary duplication of work in the Tropics and second, to furnish data along those extremely important lines that are untouched at present for lack of permanence in the work of any Station. This could well be done in cooperation with existing Stations. For example, cooperation might be arranged with the Experiment Station in Porto Rico to start plantings of varieties of coconuts. This might well last through

the administration of three or four pathologists or horticulturists, during which time notes might be lost unless kept permanently recorded by the Central Bureau.

The disease survey of Tropical America would be simply an extension of the present work that is being conducted by the several Stations. One serious fault with the present work is that many diseases are known in various countries and are never published upon as the pathologists are usually working on special problems. This work would be for purposes of quarantine legislation.

Records of quarantine and plant inspection laws of the various countries would be kept for the convenience of shippers, as it often happens now that consular agents are not as well informed upon these matters as they should be to facilitate shipping.

Publication of reports would be for the purpose of furnishing desirable data along these lines to anyone interested and to furnish a place for recording the occurrence of parasitic fungi, and to spread information as to quarantine measures.

As suggested, such a bureau might well work along several lines, but in phytopathology they would require headquarters in some such city as Washington, where the facilities for consulting the literature are good; for a staff they should have one or more entomologists and pathologists in addition to a recording clerk. The primary work of the staff would be to coordinate the work of the different Stations and to conduct disease and insect surveys. The ultimate aim of the Bureau should be to develop experts on the diseases of different crops. Thus, instead of a dozen men working on the banana disease in their own localities, one or more experts who knew the conditions in all the countries could be called upon for advice.

The success of this plan would depend largely upon the kind of coöperation offered the individual Stations. It is not proposed to supplant them in any particular whatever, but rather to serve as a medium through which their work may be coordinated, to undertake work they cannot do, and to make investigations where no Stations at present exist.

One other thing upon which depends the success of such a plan is the permanence of the institution executing it. One important motive of such an institution would be to secure permanence of work and records and unless the institution were permanent, this important motive would not be fulfilled.

Men fitted to carry on this work are unquestionably scarce. Preferably young men who have an ambition to learn new conditions, new peoples, new languages and new crops, should be selected, and if adaptable men are secured they will in a few years prove the worth of the entire plan.

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A METHOD TO INDUCE SPORULATION IN CULTURES OF BOTRYOSPHÆRIA BERENGERIANA

J. Matz

With One Figure in the Text

In working with *Botryosphæria berengeriana* De Not. it was found that it rarely sporulates in pure culture in the ordinary culture tube. This fungus was grown on oat agar, corn meal agar, prune agar, nutrient standard agar, autoclave-sterilized plugs of pecan and oak limbs, and on bean pods. A grayish green mycelium, turning black with age and some scattered stromatic bodies were produced (fig. 1, *B*), but, except in rare instances, no spores of any description were observed on any of the above media used in tubes or in plates.

When bits of Botryosphæria mycelium were inserted into wounds made with a sterile scalpel in healthy pecan twigs, the wounds subsequently being wrapped with paraffined paper, the three forms of spores, i. e., micropycnospores, macropycnospores, and ascospores were produced in varying quantities in the infected tissues (fig. 1, *A*). Reisolations of these gave grayish green mycelia, turning black with age, and some sterile stromata only. Mycelium placed in wounds on healthy pecan wood which was washed in 1 to 1000 bichloride of mercury, rinsed in sterilized water and placed in test tubes did not produce any spores.

Grossenbacher and Duggar[1] in their work with *Botryosphæria Ribis* state the following: "In pure culture this organism has borne out remarkably well its earlier reputation as a "sterile fungus," although on the hosts three conspicuous spore-forms were subsequently obtained, . . . the fungus has been grown on all of the solid media reputed to induce fruiting in culture, and many others; but only various irregular, woolly, stromatic bodies resulted, which in some cases developed perithecial bodies that never produced spores."

After several attempts with various methods at this laboratory, the following method was evolved and found successful: Healthy pecan limbs were cut into plugs about two inches long. These were placed in a glass tumbler filled with a solution of 1 to 1000 bichloride of mercury and

[1] Grossenbacher, J. G., and Duggar, B. M. A contribution to the life-history, parasitism, and biology of Botryosphæria Ribis. New York State Agr. Exp. Sta. Tech. Bul. 18 : 131. 1911.

allowed to stand in the solution ten minutes. The surfaces of these plugs were rubbed to remove air from cracks, then rinsed in sterilized water. The tumbler was left in a horizontal position to allow a thorough removal of the water. After the surfaces of the plugs were sufficiently dry, cuts were made with a sterile scalpel into the bark, and mycelium was inserted into the cuts. By using a hard needle to hold each plug at one end, the plug was plunged for an instant in molten paraffin (60° to 62°C.). In about four weeks numerous stromata were found on the paraffined plugs with pycnidia containing micropycnospores and macropycnospores identical

FIG. 1. *A*, Pecan limb artificially infected with *Botryosphæria berengeriana*. Three months from date of inoculation. Mature stromata breaking through epidermis. × 2; *B*, three-weeks-old culture of *Botryosphæria berengeriana* on a steam sterilized bean pod in a tube; *C*, the same fungus on a pecan plug which was sterilized with bichloride of mercury and coated with paraffin. Mature stromata are breaking through the paraffin coat.

with the spores of *Botryosphæria berengeriana* (fig. 1, *C*). No perfect stage of this fungus has so far been observed on paraffined plugs of wood. Mycelium from both perfect and imperfect forms were used in this method with unvarying success in abundant spore-production as described above. The cultures were started from single ascospores; from single macropycnospores (Dothiorella stage), obtained from dead bark of the pecan,

Carya illinoensis; and from bits of pecan wood tissue taken from near a region abundant with stroma containing the Dothiorella stage of the Botryosphæria. It seems that the substitute of a coat of paraffin around the plugs of wood in place of the glass tube eliminates the moist air which ordinarily exists in culture tubes and in this way suppresses the growth of aerial mycelium and induces the formation of mature stromata.

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A MELANCONIUM PARASITIC ON THE TOMATO

W. H. TISDALE

WITH THREE FIGURES IN THE TEXT

INTRODUCTION

A black spotting of tomato fruits in the horticultural greenhouse at the University of Wisconsin was brought to the attention of the writer in January, 1915. About twenty per cent of the fruits in one section of the house were more or less spotted. The disease occurs on fruits at any age and results in considerable damage. Should the trouble become widespread it would likely be of considerable economic importance.

SYMPTOMS OF THE DISEASE

The lesions first become visible on green fruits as irregular, brownish spots, which later become darker in color and finally black. Surrounding the spots, in some cases, there are sunken areas, or slight depressions. The spots are small, seldom reaching an eighth of an inch across. The skin of the ripe fruit may be slightly yellow around the spot but it usually retains its normal color. The line of demarcation between diseased and normal tissue is sharp. The spots may be numerous, and they occur on fruits of all sizes both green and ripe. The central portion of the spot is slightly raised above the surrounding, sunken area in some instances. The diseased tissue is of a tough, corky consistency. The spots, which occur independent of wounds, are confined to the superficial layers of the fruit (fig. 1).

The symptoms of the disease, when produced by artificial wound infection, are considerably different. Sunken areas are produced which are light to dark brown on mature and ripe fruits and black on young fruits. One spot may involve the entire side of a fruit. There is a distinct zonation in most cases, the zonation rings being of a darker color than the diseased area in general (fig. 2). After the spots are ten to twelve days old, yellowish specks, which are rudimentary acervuli, can be seen beneath the epidermis. These push through the cuticle in the form of an erumpent mass of whitish mycelium, which produces a black mass of spores. Spore masses are also produced in the carpellary cavities of the fruit.

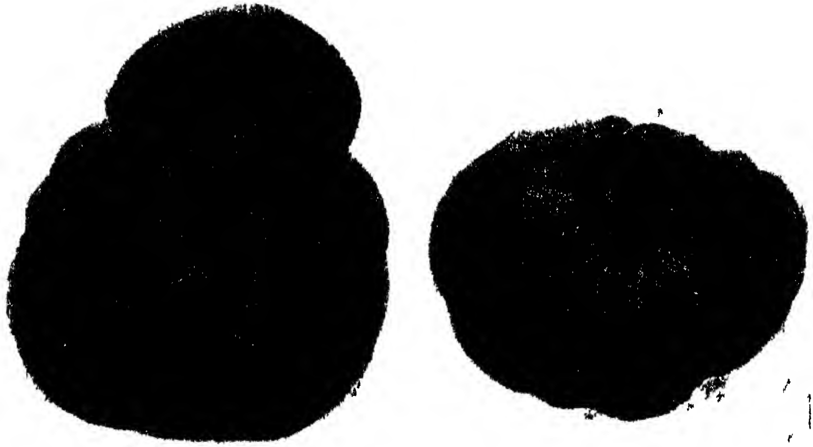

FIG. 1 Two green tomato fruits showing the superficial type of spot as produced by natural infection with Melanconium

FIG 2 Four tomato fruits infected by inserting spores of Melanconium into needle punctures Fruits at any age are readily infected by this method Notice the sunken type of spot with concentric markings

THE CAUSAL ORGANISM

The mycelium of the fungus is white or hyaline, branching, and septate. The diameter of the hyphae is fairly uniform, being about three microns. The conidiophores are short, unbranched, hyaline, and closely compacted together in an upright form, producing an acervulus. They arise from a definite basal stroma and produce spores singly at the apex. Conidia are one-celled, cylindrical, with rounded apices, light green when single and black in mass, 2 to 4 by 7 to 10μ. Spores placed in hanging drops of tomato decoction at 23° and 27°C. germinated perfectly in a few hours (fig. 3, *A* and *B*).

A large number of species of Melanconium have been described, which, for the most part, are saprophytic on twigs and the bark of forest trees. The writer has not been able to find any report of the occurrence of Melan-

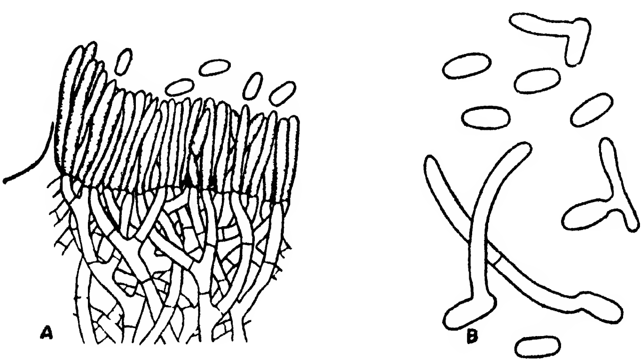

FIG. 3. *A*, Drawing to show the fungal part of an acervulus produced by Melanconium on the tomato fruit From microtome section; *B*, Melanconium spores germinated and ungerminated.

conium on tomatoes. The fungus corresponds fairly well, with the descriptions of the genus as given by Saccardo,[1] Engler and Prantl,[2] and Stevens,[3] but varies so widely from other described species in its mycological characters, to say nothing of its parasitic nature, that it appears to be an undescribed species. A Melanconium which is morphologically identical with the tomato parasite was found growing saprophytically on onions in the same greenhouse by J. C. Walker. When green tomatoes were inoculated with this species, or strain, it failed to prove parasitic, while, on the other hand, the tomato organism was very destructive.

[1] Saccardo P. A. Sylloge fungorum.

[2] Engler, A and Prantl, K Die Naturlichen Pflanzenfamilien.

[3] Stevens, F L The fungi which cause plant diseases, p. 553-554. 1913.

The author hesitates to burden the genus, which is already extensive, with another binominal. Should the disease become of considerable economic importance, however, it would probably be expedient to apply a specific name.

CULTURE

The fungus is not easily isolated from the superficial type of spot. It was first isolated on oat agar by the fragment-culture method. After isolation the organism grows fairly well on any of the more commonly used media. The superficial mycelium is white and very profuse. On corn-meal agar, however, it becomes greenish gray with age. The black spore-masses are not produced on potato agar to which no dextrose is added. On tomato, oat, and corn-meal agars the spore production is about the same. The spores are produced in disk-like masses which are very black and have a glistening, moist appearance. Very young spore masses are deep grass-green in color. The mycelium holds its uniform diameter on all media used.

INOCULATIONS

The disease was reproduced on both green and ripe fruits on plants in the greenhouse. By spraying with a spore-suspension in water the superficial type of spot was produced. In this case infection was obtained only in those cases where the fruits were wrapped with moist cotton after spraying. The cotton was removed in from one to two days. The wound type of spot (fig. 2) was very easily produced by inserting spores into the fruits by needle pricks. This proved to be a sure way

TABLE 1

Inoculation Experiments

DATE OF INOCULATION	FRUITS INOCULATED	METHOD OF INOCULATION	RESULTS
January 16	5 green	Needle prick	All infected
January 16	3 green	Sprayed and not wrapped	No infection
January 21	3 mature	Sprayed and wrapped	One infected
February 6	7 green	Needle prick	All infected
February 13	12 green	Sprayed and wrapped	Four infected
March 2	3 green	Pricked and sprayed	All infected
March 18	10 green to ripe	Needle prick	All infected
March 27	9 green	Sprayed and wrapped	Four infected. Stem of one fruit attacked
April 5	12 green	Sprayed and wrapped	One infected

of infection. Both types of spot were produced on the same fruit by spraying a cracked fruit with a spore-suspension and wrapping with moist cotton. The wound type of spot was produced where the fruit was cracked and the superficial spots on the uninjured surface. In one case, as will be noted in the preceding table, the stem of a fruit was attacked. The fruit fell and acervuli were produced on the stem. The preceding table shows the results of inoculations.

The results show that the fungus grows very readily on tomato fruits when introduced by wounds. It is also able to attack fruits which are apparently uninjured if the moisture conditions are suitable for germination and growth.

WHITE FLIES AS CARRIERS

One noticeable feature in the greenhouse where the disease first developed was the abundance of white flies. It occurred to the author that these flies were probably carrying the spores of the fungus from plant to plant. There is no reason why this should not be the case as the acervuli break through the cuticle and the spores, which are borne in abundance, are very easily detached. Indications of the disease being spread in this manner were found later in the experimental plot when the white flies got into that section of the greenhouse. In this case the disease soon appeared on wounded fruits where inoculations were not made with the Melanconium.

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A PARASITIC SACCHAROMYCETE OF THE TOMATO

ALBERT SCHNEIDER

WITH FOUR FIGURES IN THE TEXT

The more careful study of food products impelled by the enforcement of the pure food acts, federal as well as state, is revealing some new and interesting problems in cellular biology and in parasitology. We are beginning to get a better insight into the sources of certain food contaminations and deteriorations and the causation of the more important infections of the vegetable as well as animal products employed in the preparation of food materials.

Within recent years the United States Bureau of Chemistry has given considerable attention to the critical examination of tomato products, such as canned tomatoes, catsups, tomato pastes, and those products which contain tomato additions, as soup stocks, pork and beans with tomato, and so forth. The writer has made a microscopic study of the tomato in order to ascertain the normal histologic characters of this fruit. This led to the discovery of the sphaerocytes which have been reported upon elsewhere.[1] It would appear that the sphaerocytes are important factors in the ripening processes of fruits. A voracious yeast devouring ameba of the decaying banana has been described.[2] A heterogamous ameba of the decaying tomato has been noted. A parasitic ciliate has been found in tomatoes imported from Mexico. This ciliate resembled *Leishmania tropica* in its morphological characteristics.

A most interesting organism was recently isolated from tomatoes obtained from a Berkeley, California, restaurant. The restaurant proprietor maintained that the tomatoes came from the South Sea Islands. It is more likely, however, that they came from Mexico or perhaps from Cuba. The organism proved to be a saccharomycetous ascomycete parasitically associated with the ripe tomato. The affected tomato appeared normal excepting an area about two centimeters in diameter which was slightly depressed and of a peculiar dull, reddish brown color. The epidermal tis-

[1] The sphaerocytes of plants and their possible significance in plant growth and in neoplasmic formations. Pacific Pharmacist 9: 147–155. November, 1915.

Die Blasenzellen der Pflanzen und ihre Bedeutung zur Erklarung Neoplasmischer Bildungen. Deutsch-Amerikanische Apotheker-Zeitung. November, 1915.

[2] The sphaerocytes of plants and the saccharophagous amebas of decaying bananas. Merck's Report. February, 1916.

sue was markedly indurated and somewhat shriveled, but the hypodermal tissue as well as the parenchymatous tissue underneath appeared to be nearly normal. The microscopical examination showed the presence of a fungus in the seed-chamber and in the mucilaginous tissue surrounding the seeds, as well as in the parenchymatous tissue beneath the epidermis.

The affected material proved of special interest because every slide mount examined showed the complete life cycle of the organism, including the formation and development of the highly polymorphic vegetative cells and the various stages of gametic fusion and of ascospore formation, and also the formation of the arthrospores. The vegetative cells multiply by budding as typified by the saccharomycetes generally. The normal vegetative cells may be described as ellipsoid to distinctively ovoid, without vacuoles or recognizable nuclei. The plasmic contents line the inner wall of the cell and accumulate at the poles, usually more abundant at the larger end or at the distal end of the cell in case of cell aggregates. The vegetative cells may, however, undergo remarkable changes in form. They may be greatly elongated and variable in width. Occasionally the elongated cells give a very close resemblance to true hyphal fungi. Occasionally a single cell may become bent or elbowed or narrowed at one end resembling a gourd. Daughter cells are always developed apically, never laterally, as is the rule in the majority of the group Saccharomycetes. The exceptions are the cells which form at the junction of two cells. Daughter-cell formation is usually bipolar, that is, starting with a single vegetative cell, new cells may form from both apices (fig. 1).

The plasmic substance of the cells, inclusive of that of the arthrospores, appears to be homogeneous. On the exterior of this homogeneous, absolutely colorless, plasmic substance there are usually a few comparatively large spherical, colorless, highly refractive granules which are no doubt the true plasmic granules. They measure about 0.5 micron in diameter and are very uniform in size. In the vegetative cells they are very sparingly present, there being from one to three or four. They are more abundant in the arthrospores, from five to as many as one hundred being present. The plasmic granules stain readily. They are slightly actively motile and show remarkable Brownian vibration. No Brownian vibration is noticeable in the granules of the dying or dead cells or spores.

The ascospores are formed in spore sacs which result from the gametic union (isogamous) of two normal, elliptical, vegetative cells. The cell membrane is dissolved at the point of contact. The plasmic contents gather at the contact ends of the gametes and as the membrane is dissolved the plasmic substances of the two cells fuse. The complete changes are shown in figure 3. Eight spores are formed in each spore sac. At an

early period in the development of the spore sac (ascus) the associated vegetative or somatic cells become disconnected and the spore sac exists as an independent cell structure. There are indications that a spore sac may be derived from a single vegetative cell, without gametic fusion of cell plasms; especially does this appear to be the case under conditions of very active ascospore formation.

As a rule, active ascospore formation occurs simultaneously with active arthrospore formation. The end effort appears to be arthrospore formation under conditions unfavorable to the continued existence of the organism. The arthrospores are simply enlarged vegetative cells which take on a spherical form and are remarkable in that they invariably continue to maintain the originally bipolar position in the suspending liquid. Thus, when examined under the compound microscope, it will be found that the nucleus, with the surrounding homogeneous, plasmic substance and the plasmic granules, occupies a lateral position on the inside of the cell so that an edge view is always presented, as indicated in figure 2, *A*. In not a single instance was the spore to be seen in exactly vertical view. Very rarely was the spore sufficiently tilted to present the view shown in figure 2, *A*. The cell-wall becomes thickened and there is an increase in the number of plasmic granules, as already indicated. There is a small group of plasmic granules at the pole opposite the nucleus. While as a rule only one cell of a group of vegetative cells becomes converted into a spore, occasionally two, three or even four such cells in a row become converted into arthrospores. The vegetative cells which do not change into spores soon become dissociated, as in the case of ascospore formation. Occasionally arthrospores take on the gourd form as shown in figure 4.

The ascospores are two-celled, rather slender and taper to a point. The two cells differ materially. The cell which is directed toward the middle of the ascus and which contains the cilium or ligule, stains very heavily. The ligule which is entirely motionless appears to be gelatinous in character and serves the purpose of attaching the spore to its fellows in the group of four, and also to other objects with which the spore may accidently come in contact. There are indications that the chromatin cell of the spore serves as a source of food supply for the vegetative achromatin cell which is concerned in starting a new cycle of cell-formations by budding. The chromatin end of the spore gradually shrinks and the residual or unused portions of the cell contents disintegrate and dissolve in the surrounding medium.

The fungus is a true parasite, as it develops in and upon living tissues and will not develop in the presence of decay. Upon the death of the tomato tissues and the accompanying invasion by the rotting bacteria and molds, this organism at once enters upon very active spore formation,

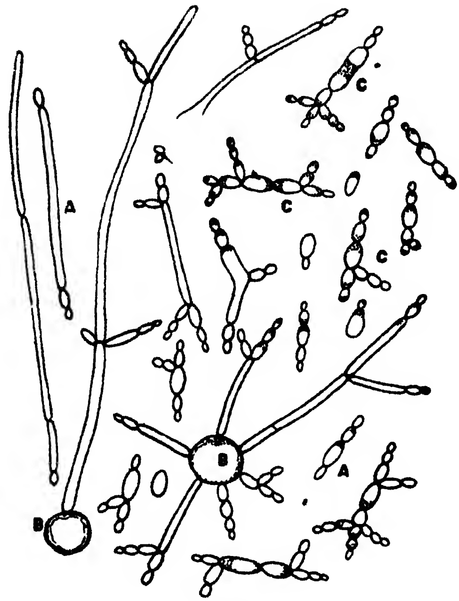

FIG. 1

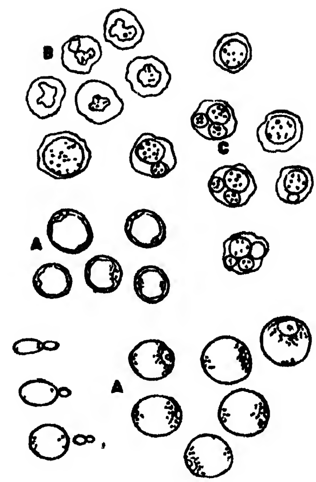

FIG 2

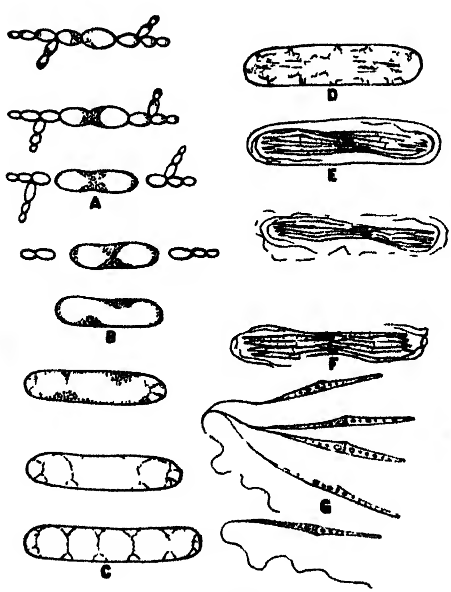

FIG 3

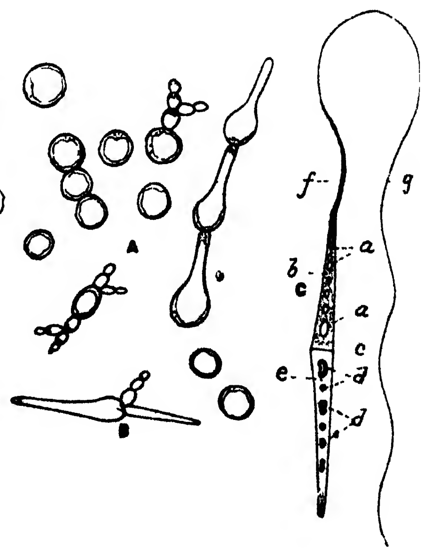

FIG. 4

ascospores as well as arthrospores, and all vegetative cell-formation ceases. The final activity consists in the conversion of the vegetative cells into arthrospores. The cells of the final crop of arthrospores are unusually large and the plasmic granules are increased in number. Death of the arthrospores is frequently preceded by sphaerocyte formation. That is, the plasmic contents of the spore gathers into one or more spheres in the interior of the cell, with the plasmic granules occupying a position within the plasm. Whether these were true sphaerocytes capable of growing and dividing or mere plasmic spherules could not be ascertained. In most instances sphaerocyte-formation was the precursor of the death of the plasm.

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EXPLANATION OF FIGURES

FIG. 1. *A*, Various forms of vegetative cells of the Saccharomycete. Extremes in cell formation are not shown. Very frequently the hyphal filaments resemble the hyphae of a true mold but the individual cells do not branch as in the true molds; *B*, arthrospores; *C*, the beginning of spore sac formation.

FIG. 2. Arthrospore formation. *A*, stages in the formation of arthrospores; *B*, dying spores. The plasmic substance has gathered in the middle of the cell (plasmolyzed); *C*, Sphaerocyte formation within the arthrospore as explained in the text.

FIG. 3. Various stages in the fusion of the plasmic contents of the gametes. *A*, two vegetative or somatic cells unite end to end with solution of the contact cell walls; *B*, the plasmic contents of the gametes fuse; *C*, the fused plasm again becomes septate; *D*, division proceeds to the formation of eight spores forming plasmic masses which soon draw away from the cell wall and gather in the middle of the ascus; *E*, fully formed spores, eight in number; *F*, the ascus membrane soon gelatinizes and dissolves, completely setting free the spores which remain attached to each other in groups of four; *G*, gradually the spores become separated and are distributed through the medium.

FIG. 4. *A*, Arthrospore formation. Ordinary vegetative cells are gradually transformed into spores; *B*, an ascospore beginning a new vegetative cycle; *C*, detailed structure of a mature ascospore highly magnified; *a*, vacuoles in the chromatin cell of the spore; *b*, chromatin substance; *c*, transverse septum; *d*, plasmic masses in the achromatin cell of the spore; *e*, achromatin; *f*, the portion of the filament or ligule which stains very heavily; *g*, the greatly elongated gelatinous filament by means of which the spore attaches itself to various objects with which it is brought in contact. The ascospore is distinctly two-celled. The spore wall as well as the septum are thin. There is a distinct widening of the spore at the transverse septum, *c*.

THE LONGEVITY OF BACILLUS AMYLOVORUS UNDER FIELD CONDITIONS[1]

J. W. Hotson

With Four Figures in the Text

The fire-blight organism has been the object of much observation and experimentation by a large number of investigators in various parts of the country, both in the laboratory and in the field. Among other phases of investigation the length of time the organism may live under different conditions has received some attention. Most of this work has been done in the laboratory with pure cultures of the organism although some attempts have been made to determine the longevity of the Bacillus under field conditions.

In a cultural study of *Bacillus amylovorus* (Burr.) Trev., Stewart[2] has shown that the thermal death-point of this organism is about 47°C. when exposed for ten minutes. He has further shown that when cultures in petri dishes are exposed to direct sunlight for four hours the organisms are killed. Referring to this organism, O'Gara[3] states "It is killed by exposure to direct sunshine in a very few minutes, usually not more than ten minutes unless protected by the bark. . . The germs are killed by high temperature. They are wholly destroyed when subjected in a liquid culture to a temperature of 55°C. for ten minutes." These statements which may be perfectly true when taken in connection with the context have misled some of the growers of the Yakima Valley in Washington who argued that if the organisms are killed by the sunlight in four hours or by heat which in the Yakima Valley often reaches 50°C. in the sun, there is no objection to leaving amputated blighted branches under the trees until it is convenient to remove them. Moreover, in the treatment of active cankers, especially those on large limbs, other orchardists grasping at this "light and heat straw" conceived the plan of cutting off the outer protective layer of bark without penetrating as deeply as the cambium. With this outer portion of the bark removed it was believed the sun should kill the organisms left in the inner bark. The advantage of this mode of treatment over the usually accepted method

[1] Abstracted in Phytopath. 6: 115. 1916.

[2] Stewart, V. B. The fire blight disease in nursery stock. Cornell Univ. Agr. Exp. Sta. Bul. 329: 317–371. 1913.

[3] Lowther, Granville. Encyclopedia of practical horticulture 3: 1622.

of shaving off the diseased bark down to the sapwood and disinfecting the wound is that, if it is effective, a portion of the cambium will still be left, which will eventually heal over the whole wound. Again, it was argued that if a narrow band of the outer bark is cut off, in the manner just mentioned, above and below an active canker, the organisms will not cross this strip because the sunlight will kill them. In this way the cankers may be prevented from spreading up or down the limb and the organisms may eventually die out

Questions of this nature became of such interest to many of the best growers in the Yakima Valley that numerous experiments bearing on the subject were performed by the writer in an effort to get at the facts in the matter. The object of these experiments was to obtain, if possible, some definite information regarding what actually occurs in the orchard, how long fire-blight organisms live in the dried-up exudate; how long they live in infected branches that are left under the trees, in deep grass, or in clear cultivation; and also the effect of sunlight on the organisms in cankers that have a thin outer layer of the bark removed.

It has already been shown[4] that in the case of the invasion of the leaves by *Bacillus amylovorus* the bacteria apparently soon die, seldom producing "twig infection as a result of the organisms working back through the petiole."

LONGEVITY OF BACILLUS AMYLOVORUS IN AMPUTATED BRANCHES

Fulton[5] has reported some work along this line with the result that, "Out of 35 twigs, 31 twigs, or about nine-tenths were inactive at the end of seven days; and the majority of these had become inactive in three to five days." He concludes that "the quick death of blight bacteria in cut twigs, and the remote chance of their being transferred to living trees, brings in question the necessity for rigid destruction of blighted twigs after their removal." In this account nothing is said as to the size of the "twigs" used but it is inferred that they were small, possibly terminal infections. The writer infers this not only from the use of the word "twig" but because he obtained practically the same results as described by Fulton with small branches of terminal infections and watersprouts.

During the summers of 1914 and 1915 fire-blight was very destructive in the Yakima Valley, Washington, and in some districts the entire apple and pear industry was threatened. In several instances whole orchards looked as if a fire had swept through them turning all the leaves of the terminal

[4] Hotson, J. W. Observations on fire blight in the Yakima Valley, Washington. Phytopath. 6: 288–292. 1916.

[5] Fulton, H. R. The persistence of Bacillus amylovorus in pruned apple twigs. Phytopath. 1: 68. 1911.

branches brownish. Amputation of the parts infected, a foot or eighteen inches below the lowest outward evidence of the disease, was the chief remedial measure recommended for twig, blossom, or body infections.

This mode of treatment often necessitated the removal of large limbs, some of which had exudate freely oozing from the diseased bark. This process known as dehorning is illustrated in figure 1, which shows part of a young Spitzenberg orchard. Figure 4 represents a similar condition in an orchard of Bartlett pears. Not infrequently the trunks of trees became infected and it was necessary to remove the entire tree. This condition is shown in figure 2 which is a photograph of a young Spitzenberg apple tree that had been severely pruned in the hope of saving it but in which the disease spread to the trunk, producing an active, exuding canker.

Orchardists often left these large exuding branches on the ground for weeks or even months before removing them. It was only by the constant admonishment of the State Horticultural Department that these pruned branches were burned soon after they were removed from the trees.

It should be remembered that in the Yakima Valley, although the days during the summer are extremely warm the nights with few exceptions are cool, even cold at times. This is particularly true in June when the exudation from infected limbs is at its height. These cool nights are undoubtedly favorable to the growth of the fire-blight organism, since its best growth occurs between 22° and 25° C. with a gradual retardation below this optimum.

Experiment 1

Several branches about four centimeters in diameter, badly infected with blight and exuding freely were brought into the laboratory on June 7. Owing to the writer's absence they were kept standing in a pail of water for a period of ten days. On June 17 one of the branches was placed on a ledge on the southwest corner of the Yakima County court house. In this position it was subjected to the direct sunlight from 5 o'clock in the morning until 7 o'clock at night, with a temperature in the middle of the day ranging from 40° to 50°C. The other branches were left in the laboratory but not in water. Samples were taken every day from the dried exudate on the branches and gross cultures on green pears were made in a manner similar to that previously described.[6] In this experiment a portion of the dry exudate was transferred each day to the aseptic slices of pear. The characteristic milk-white beads of *B. amylovorus* were obtained for ten consecutive days. By that time the dry exudate on the branch was all used and portions of the bark about one centi-

[6] Hotson, J. W. Fire-blight on cherries. Phytopath. 5: 312–316. 1915.

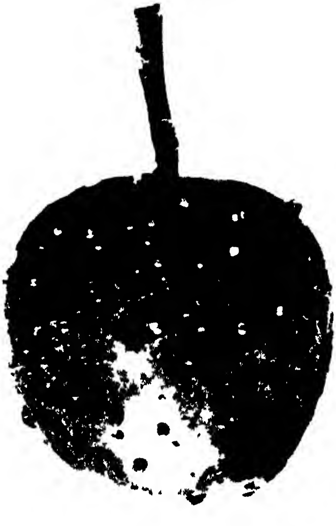

Fig. 1. A young Spitzenberg orchard that has been "dehorned" in an effort to control fire-blight.

Fig. 2. A four-years-old Spitzenberg tree reinfected after it had been "dehorned."

Fig. 3. A Jonathan apple showing beads of exudate produced by *Bacillus amylovorus*. Photograph made by Henry Schmitz.

meter square, extending to the cambium, were taken as samples. The wounds thus made were immediately covered with soft grafting wax to avoid excessive evaporation at these points. This was continued for several weeks, the typical fire-blight exudate being obtained up to July 5, that is, eighteen days after the experiment began or twenty-eight days after the branch was taken from the tree. The limbs that were kept in the laboratory yielded living organisms up to July 16 or thirty-nine days after they were cut from the tree.

FIG. 4 Pruning Bartlett pear trees that are badly infected with fire-blight.

Experiment 2

On June 29 a pear that had already turned black and hard and with a large bead of exudate on it was exposed to the direct sunlight in the same place as the apple branch mentioned in Experiment 1. When this exudate was transferred to slices of pear in the manner already mentioned, living fire-blight organisms were obtained with the characteristic white beads of exudate on July 12 or after thirteeen days' exposure to the direct sunlight.

Experiment 3

A blighted branch that was exuding freely was exposed to the weather on June 30 in such a position that the direct sunlight was on it about half of each day. During the period of exposure of the branch there were two periods of light rainfall, one of which lasted practically the whole

day, the other occurring at night. Samples of bark about one centimeter square were taken from this branch every two days and treated similarly and with the same care as in Experiment 1. The living organisms were regularly obtained up to July 26, i.e., twenty-seven days from the time the branch was first exposed.

Experiment 4

On June 29 a Jonathan apple, shown in figure 3, covered with beads of exudate was exposed to the direct sunlight in the same location as that mentioned in Experiment 1. These beads of exudate were tested in the same way as the others and the characteristic results of fire-blight were obtained up to July 12 or fourteen days after the apple was removed from the tree. Another Jonathan apple infected in a similar way and obtained from the same bunch on the tree as the one just mentioned, was left in the laboratory. The latest date of obtaining living blight organisms from it was July 13 or fifteen days after the fruit was picked. These apples were only about half rotted when they were picked. They would thus tend to retain the moisture and probably this assisted in keeping the bacteria alive a little longer than in the withered fruit referred to in Experiment 2.

Experiment 5

On July 12 several blighted Spitzenberg branches were left in an orchard in which there was a cover-crop of alfalfa. Similar branches were placed on the ground in a clean cultivated orchard. Cultures were taken from these at intervals of two days for eighteen days and every day after that. The last living culture from the former samples was obtained August 10 or twenty-nine days after the branches were cut from the tree, and from the latter, on August 6, the organisms having held their vitality twenty-five days. This was repeated several times with about the same results, the maximum exposures from which living bacteria were obtained varying from twenty to thirty-five days.

The branches left in the alfalfa invariably showed living organisms longer than similar branches on clean-cultivated soil. This difference was usually only a day or two but occasionally it was as long as five or six days. Moreover, the branches in dense alfalfa with plenty of irrigation water showed a distinct tendency to ooze. The exudate, if hard, often became soft making it possible for insects to carry away some of the germs. In none of the other experiments was there any indication of the exudate softening or oozing.

Tests were also made by using infected terminal twigs and water-sprouts. In these cases the vitality of the organism was much shorter, seldom re-

maining active beyond the fifth day. In a few instances where the twigs were left in tall irrigated alfalfa, living organisms were found after seven days. As has been said these results correspond fairly well with those of Fulton in which the bacteria "became inactive in three to five days."

TREATMENT OF ACTIVE CANKERS

The following method of treating active cankers on large limbs has probably been tried elsewhere but as far as the writer is aware no definite account of it has been recorded. This treatment consists of shaving off the outer bark of the canker much after the fashion of the usually recommended mode of procedure for treating cankers except that the bark is not removed down to the sapwood but a thin layer of cambium is left. The same precaution is taken to get beyond the infected areas as in the usual method of treating cankers. Under these conditions, the sunlight should penetrate the remaining thin layer and destroy any living organisms. The observations on this experiment were made in two different orchards. The orchardists in charge of these two places obtained this suggestion by reading the articles by Stewart and by O'Gara. In both of these articles, statements are made concerning the destructive effect of light and heat on the fire-blight organism. The only suggestion the writer offered was the desirability of washing the wound with some disinfectant after shaving the bark off, preferably a weak solution of lysol. One of the orchardists took the suggestion, the other did not. These orchards were visited on an average of once each week during the summer. Observations and notes were made on the different trees treated. Samples of the bark were frequently tested for blight by the green-pear method previously mentioned.

In the first orchard between fifty and sixty trees mostly Comice pears were treated. The orchardist was so confident that the method would be successful that he did not use a disinfectant of any kind. He used a large jack-knife and shaved off the bark of oozing cankers without sterilizing the knife or the wound. He was always careful, however, never to allow the blade of his knife to go deeper than the shaving he was cutting off. With each stroke of the knife a whole shaving was separated from the tree. Thus, by a series of rapid strokes, portions of the bark were taken off, always leaving a portion of the cambium intact. The argument used by the orchardist for not disinfecting the tools or wounds was: "If my theory regarding the sunlight killing the organisms is correct, then those germs that are rubbed off the blade of the knife on the fresh cut surface should be killed by it as well as all the other fire-blight bacteria in the thin layer of bark that is left. There is no chance for the organism to get

into the tissue of the bark because a complete shaving is cut off with every stroke. It is, therefore, a waste of time and an additional expense to sterilize the knife and wounds after each operation." In spite of this crude method of treating the canker it was remarkable how few secondary infections were made. In forty per cent of the cankers treated in this way the blight later extended beyond the treated areas. In practically all cases new cambium was formed apparently healing over the wound. In a few instances of these latter, however, it was determined by making gross cultures that the organisms had remained alive next to the cambium layer. This was probably due to a failure to remove sufficient bark as in these cases the bark which remained was thicker than elsewhere. These few cases are likely to prove the most dangerous as they probably will develop into hold-over cankers and thus cause increased infection another year.

In the second orchard more care was taken. The cankers were carefully peeled, an effort being made in each case to cut beyond the affected area. The wounds made were well washed with a four per cent solution of crude lysol. A much weaker solution, however, would probably have done just as well. Lysol or crude creosote is preferable to corrosive sublimate because of its penetrating power. Much better results were obtained in this orchard than in the first. Even here, however, instances occurred where the blight later extended beyond the treated area. Although the cambium began to grow over practically all of these wounds yet the growth was much slower and uncertain than in the first orchard. This was probably due to the use of an injurious strength of the disinfectant.

The writer compared the results in this orchard with others in which the usually accepted mode of treatment of active cankers was practised, namely, to cut out all the infected bark down to the sapwood and to disinfect the wound. In order to insure reaching beyond the infected area the bark is removed a foot or eighteen inches beyond the apparent limits of the canker as seen in the outer bark. The proportion of successful operations in these two orchards was practically the same. Those that proved unsuccessful in both cases were usually due to a failure to cut beyond the infected area in the original canker so that the organism continued its work.

In cases where a band of the outer bark is cut below and above a canker to prevent its spreading there is no advantage over the regularly accepted method of treatment. Although either of these treatments may stop the spread of the canker, yet in the former method there is nothing done to prevent it from oozing and becoming a source of infection to other trees.

CONCLUSIONS

These experiments clearly show that the fire-blight organism (*Bacillus amylovorus*) under field conditions, at least under those found in the Yakima Valley, lives longer than has been generally supposed from work with artificial cultures. The reason for this is readily seen in the protection these organisms obtain from the bark of the tree and the hardened gelatinous envelope caused by the drying of the exudate. The process of killing is often although not always, simply that of desiccation. The larger the limbs that are cut off and the larger the beads of exudate the longer does the organism retain its vitality. In a similar way the amount of moisture surrounding the blighted branch after it is cut off determines to a large extent the length of time the organisms will live. This is especially true where the temperature is reasonably low, from 15°C. to 18°C. If blighted branches are cut off and left in a cover-crop of clover or alfalfa the protected organisms may retain their vitality a month and at the time of irrigation or rain the exudate may soften and begin to ooze, thus becoming a source of further infection. Unless the branches are thus moistened they may not exude and therefore may not be a source of infection, but it is wisest to burn the branches as soon as possible after they are cut off.

In treating active cankers by peeling the bark so that a portion of the cambium is left, there is a possibility of this mode of treatment being of some real value in attempting to save large limbs provided that only a thin layer of bark is left. It is important that the cut surface be treated with some disinfectant such as lysol or creosote, weak enough that it will not injure the cambium cells of the tree and yet having sufficient strength to kill the bacteria when it penetrates the remaining bark. A one per cent solution is probably strong enough to accomplish this purpose. More experimental work, however, should be done before it is safe to attempt anything on a large scale or to place explicit confidence in this mode of treatment. With care there probably will be no more failures than by following the usually recommended method. It has, moreover, this decided advantage that the cambium eventually grows over the whole wound, saving the limb.

In practically all the cankers treated in this way the cambium began to grow within a few weeks and by autumn many of the wounds were completely covered. Even in those cases where the blight organisms continued to grow beyond the treated area the cambium began to develop where the bark had been removed. Many of these, however, became reinfected later because the organism was still in the old bark.

UNIVERSITY OF WASHINGTON
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REVIEWS

The Genus Phoradendron. By William Trelease, Professor of Botany in the University of Illinois. Octavo, pp. 224, pls. 245. Published by the University. Price, paper $2.00, cloth $2.50.

The leafy mistletoes of America are a very interesting group of parasitic plants attacking trees and shrubs. These mistletoes have been studied by a number of botanists, among them Torrey and Engelmann of this country. The published results of these investigations are scattered in separate publications, a number of which are not available to many plant pathologists. Considerable confusion as to the definition and limits of the species of Phoradendron in this country has existed from the beginning. The name *Phoradendron flavescens* as currently applied to a number of forms which vary so considerably as to be specifically different illustrates the conditions as to nomenclature before the present publication appeared. The present volume has assembled the present knowledge of this group of mistletoes in a concise form, well arranged, conveniently indexed, and copiously illustrated.

The genus Phoradendron is separated into two primary subgenera: the Boreales, without cataphyls on their foliage shoots, with all but one species occurring in the United States and Mexico; and the Equatoriales with cataphyls on their foliage shoots, with all species occurring in tropical or subtropical regions.

Since all the species of Phoradendron in the United States belong to the Boreales, our forest pathologists will be primarily interested in this subgenus. The Boreales are divided into three groups, two of which have representatives in the United States: the Pauciflorae, with two pistillate flowers; and the Pluriseriales, with six or more pistillate flowers to each joint.

The Pauciflorae are separated into the Aphyllae, leafless forms, possessing only non-articulating scales; and the Bolleanae, with scale-shaped articulating leaves. Of the former 4 species (1 new), and of the latter 8 species (5 new) occur in the United States.

The Pluriseriales are separated into five divisions, one of which with leaves of moderate size is represented by 12 species (3 new) in this country.

In addition to the nine species reported from the United States, several new varieties are described. In all cases specific distinctions appear to

be based on definite characters. The writer of this review has collected many specimens of Phoradendron, chiefly from the southern, southwestern, and western United States, and has made thousands of field observations involving many of the American species. It appears to him that it may be necessary in case of a few species to make a series of inoculations in order to fully establish the relationships of forms here considered distinct. This is indicated by some of the partial results already obtained by cross inoculations recently made by the writer of two species of Phoradendron on coniferous hosts. These show that the influence of the host on the parasite may exert an effect on the habit of growth in stems of the parasite, and that at least two species ordinarily considered distinct may be only forms which vary with the species of host attacked.

GEORGE GRANT HEDGCOCK

PHYTOPATHOLOGICAL NOTES

Facultative heteroecism (?) of Peridermium harknessii and Cronartium quercus. Facultative heteroecism in these two rusts is claimed by Meinecke[1] as the result of infection and field studies. Aeciospores of *Per. harknessii* sown on *Pinus radiata* produced galls, aecia, and aeciospores typical of that rust species. These results, coupled with the assumption that *Per. harknessii* and *Per. cerebrum*, the latter having been established as heteroecious, are identical, are the foundations of this claim. *Cronartium quercus* having been found capable of overwintering in the uredinial stage in the leaves of *Quercus agrifolia* is likewise said to show facultative heteroecism.

No acceptable instance of facultative heteroecism in the rusts, so far as the writer is aware, has been known and, though such a condition cannot be considered impossible, neither of the cases cited meets the requirements which should be established for this claim. The ability of these rusts to exist in the absence of an alternate host plant is indicated, but this alone does not constitute autoecism nor facultative heteroecism.

Heteroecism in the rusts implies an alternation of generations, the gametophyte (pycnia and aecia) being developed on one host or group of hosts, and the sporophyte (uredinia and telia) on another. A species must be capable of producing both generations on the host of one generation to be considered facultatively heteroecious. The overwintering of the uredinial stage of *Cronartium quercus* on the sporophytic host is merely another instance of continuous asexual propagation. Ludwig[2] has cited a number of species which overwinter in this way, and many additional ones doubtless exist.

Granting the ability of *Per. harknessii* to reinfect its host, *Pinus* sp., is the assumption of facultative heteroecism warranted? Proof of the identity of *Per. harknessii* and *Per. cerebrum*, or of the existence of an alternate host for the former, is lacking, and though similar, they must be considered distinct, in view of Meinecke's cultures, until proven otherwise. The ability of aeciospores to reinfect the host on which they are borne should be conclusive proof of autoecism, and *Per. harknessii* should, therefore, be autoecious but not facultatively heteroecious. The true

[1] Meinecke, E. P. Peridermium harknessii and Cronartium Quercuum. Phytopath. 6: 225–240. June, 1916.

[2] Ludwig, C. A. Continuous rust propagation without sexual reproduction Proc. Indiana Acad. Sci. 1914: 219–230. 1915.

character of these spores may well be questioned. Although morphologically aecidiospores, they may be acciospores, teliospores, or urediniospores in function, since all three may be borne catenulately in aecidioid fructifications. If the inoculated spores are aeciospores, the resultant spores must be urediniospores or teliospores (aeciospores do not reproduce aeciospores); if urediniospores, the same possibilities hold; and if teliospores they must produce teliospores or aeciospores. Germination studies of the spores and perhaps cytological studies of their formation may be necessary before the exact status of this species is known.

F. D. FROMME

Relation of soil temperature to infection of flax by Fusarium lini. During the past year experimental work with flax wilt has been conducted in the pathological greenhouse at the University of Wisconsin, using soil and seed courteously furnished by Professor H. L. Bolley of North Dakota. The outcome has been a confirmation under greenhouse conditions of Bolley's conclusions as to the resistance of certain strains of flax and the susceptibility of others.

A point of further interest which has developed is the relation of soil temperature to infection. A more rapid wilting of susceptible plants was noticed in flats near the heating system. Soil temperatures were taken, and it was found that the temperature in flats near the heating pipes ran from 18° to 20°C., while the temperature in flats near the center of the greenhouse, where there was much less infection, ran from 14° to 17°C. At the opening of spring when the temperature in these flats rose above 17°C. practically all of the plants of the susceptible strain wilted. Since there was some infection below 17°C., this seemed to indicate that the critical temperature for the infection of flax by *Fusarium lini* Boll. is somewhat below this point. This was of interest since Gilman (Phytopath. **4**: 404. 1914), found that the critical temperature for infection of cabbage by *Fusarium conglutinans* Wollenw. is about 17°C.

Following these observations by the writer an attempt was made to control the soil temperature and to determine more accurately the critical temperature for infection of flax by *Fusarium lini.* By means of a water jacket around the pots the temperature was held fairly constant at the desired points. It was found that at temperatures below 15°C. no wilting of flax plants occurred, while plants in a control pot where the temperature ran from 19° to 21°C. wilted rapidly. When the temperature was held at 13° to 14°C. the flax plants grew fairly well and no indications of wilt were evident. However, when the temperature was allowed to run above 16°C. for one day or more some of the plants in each case became infected, as could be seen by the appearance of wilt symptoms within three days, even when the temperature was subsequently lowered. This

experiment was repeated with similar results. This indicates that the critical temperature for infection of flax by *Fusarium lini* is about 15°–16°C.

W. H. TISDALE

Phacidium infestans on western conifers. In the spring of 1913, after the disappearance of the snow in the lateral valleys of the Pendd, Oreille River drainage in northern Idaho, the reproduction of *Abies grandis* and *Pseudotsuga taxifolia* was observed in several locations to be in a dead or dying condition. Those seedlings which had remained longest under the snow were practically all dead. An examination of the affected plants showed the needles to be uniformly attacked by a fungus which was not critically examined at the time. In July of the same year the reproduction of *Abies concolor* in certain valleys of the Whitman National Forest, Oregon, was found attacked by a fungus under conditions exactly similar to that of the grand and Douglas firs in Idaho. A study of a quantity of material from both regions showed that the needles were infected by *Phacidium infestans* Karst. This fungus is practically unknown in this country as a cause of a serious disease of forest growth, and its general characteristics should be made known.

The symptoms of the disease on our western conifers are similar to those described by Lindberg[1] and Lagerberg[2] in the northern province of Sweden. The fungus attacks only those needles which are covered by the snow. This is shown by the fact that the upper part of the crowns of young trees not covered by the snow is always free from the fungus. This gives to the general reproduction in regions where the disease is serious a very striking appearance. The infected needles remain attached to the tree and soon after the disappearance of the snow assume a brown color, which later in the season changes to an ashen gray. The apothecia of the fungus begin to appear on the under side of the needles about June, rupturing in the characteristic manner of the genus, and produce mature spores from August to October. The lobes of the apothecia eventually fall away, usually during the following year, leaving a cavity in the tissues of the needle after the manner of *Keithia thujina* Durand on Thuja. The needles become paler in color and remain attached until broken off by wind or snow.

So far the fungus has not been discovered in any forest tree nursery, but the fact that natural reproduction succumbs very rapidly to an attack makes it a possible menace in all nurseries where firs are grown. Whether or not the fungus is confined in this country to firs is not known. No

[1] Lindberg, Fred. *Thelephora laciniata* flikig barksvamp, och *Phacidium infestans*, snoskytte, två stora skadegörare, i de norrländska plantskolorna. Skogsvårdsföreningens Tidskrift, häfte 9, 1914.

[2] Lagerberg, Torsten. Tallskytte och snöskytte. Skogen, May, 1915, p. 117–26.

collections have as yet been made on pines in this region. In the northern provinces of Sweden pines are chiefly attacked and the fungus is seriously interfering with reforestation. So far *Phacidium infestans* has been collected on the following hosts: *Abies grandis, A. lasiocarpa, A. concolor,* and *Pseudotsuga taxifolia*, and seems to occur chiefly between the fortieth and forty-fifth degrees of latitude. In Sweden the fungus is reported to occur but rarely below the sixtieth degree of latitude.

JAMES R. WEIR

Pinus ponderosa and P. jeffreyi, hosts for Razoumofskya americana. This parasite, which has only been reported on *Pinus contorta* and *P. banksiana*, has recently been found by the writer in the vicinity of Coeur d'Alene Lake, Idaho, and also at Sumpter, Ore., on *Pinus ponderosa*. In a recent letter to the writer, Mr. J. S. Boyce, of the Office of Investigations in Forest Pathology, Department of Agriculture, reports the finding of *R. americana* on *Pinus jeffreyi* in the Little Grizzly Valley, Plumas National Forest, California. The discovery of these new hosts has been expected since the common mistletoe of *Pinus ponderosa*, viz: *Razoumofskya campylopoda* (Engelm.) Piper, is occasionally found on *Pinus contorta*. Sometimes both parasites are found on the same tree of either species.

The effect of *Razoumofskya americana* Nutt. on *Pinus ponderosa* is the same as that on its other hosts. Large witches'-brooms are produced, in some cases involving the entire crown, causing serious suppression.

The host relation of these two parasites indicates that any one of the mistletoes of the hard or yellow pines may be expected to occur occasionally on any member of the group other than the species on which it is of economic importance. On the other hand, the false mistletoes (Razoumofskya) very rarely occur outside the host genus.

JAMES R. WEIR

Personals. Dr. Donald Reddick of Cornell University has been granted sabbatic leave and will spend the ensuing academic year at Johns Hopkins University where he will be engaged in special work in plant physiology. Matters pertaining to *Phytopathology* should be addressed to him at the Laboratory of Plant Physiology, University Parkway, Baltimore, Md.

Dr. A. J. Mix, assistant botanist at the New York (Geneva) Agricultural Experiment Station, has been appointed Instructor in Plant Pathology, in the Department of Botany, University of Kansas, Lawrence, Kansas.

Dr. J. L. Weimer, instructor in plant pathology, Cornell University, has been appointed assistant botanist in the Purdue University Agricultural Experiment Station, Lafayette, Ind., and has entered upon his duties in connection with the rust investigations.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

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Brooks, A. B. The chestnut blight and the white pine blister rust. West Virginia Dept. Agr. Bul 12, 21 p, illus 1916.

Endothia parasitica (chestnut blight).

Carpenter, Clarence Willard. The Rio Grande lettuce disease. Phytopathology **6**, no. 3: 303-305, 1 fig. June, 1916.

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Cauthen, E. F. Wilt resistant varieties of cotton. Alabama Agr. Expt. Sta. Bul. 189: 67-88, illus. 1916.

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Czarnecki, Helen L. A Gloeosporium disease of the almond probably new to America. (Abstract.) Phytopathology **6**, no. 3: 310. June, 1916.

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Duggar, Benjamin Minge. Rhizoctonia solani in relation to the "Mopopilz" and the "Vermehrungspilz." Ann. Missouri. Bot. Gard. **3**, no. 1: 1-10. February, 1916.

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Discussion, p. 514-521.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Erwin, Arthur Thomas. Using potatoes infected with late blight for seed purposes. Rpt. Iowa State Hort. Soc. **50** (1915): 420–423, illus. 1916.

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PHYTOPATHOLOGY

VOLUME VI NUMBER 6

DECEMBER, 1916

STUDIES IN THE LIFE HISTORIES OF SOME SPECIES OF SEPTORIA OCCURRING ON RIBES

R. E. Stone

With Two Figures in the Text

SEPTORIA RIBIS DESM.

In a previous communication[1] it was stated that *Septoria ribis* Desm., occurring on *Ribes nigrum*, has for its perfect stage *Mycosphærella grossulariæ* (Fr.) Lindau.[2] The report was based largely on work done with the fungus as it occurs on the black currant. At the present time more evidence has accumulated on this fungus and the ones occurring on other species of Ribes which makes a further account advisable.

Septoria ribis Desm., was described in 1842 on material from *Ribes nigrum* and the name has since been applied to similar forms occurring on other species of Ribes. That *Mycosphærella grossulariæ* (Fr.) Lindau, is the perfect stage is shown by the following data: (1) *Mycosphærella grossulariæ* is found constantly upon old over-wintered leaves of *Ribes nigrum* following an attack of *Septoria ribis* Desm.; these observations have been made in the springs of 1913, 1914, 1915 and 1916. (2) If leaves infected with *Septoria ribis* are placed out of doors in wire baskets, they will bear, the following spring, *M. grossulariæ*. Leaves so infected were placed out doors in the autumns of 1913, 1914 and 1915. (3) If leaves bearing perithecia containing viable ascospores are included within moist chamber with a healthy currant plant and then sprayed, the green leaves, in ten days will show the typical spotting due to *Septoria ribis* and in twenty days will show typical pycnidia and spores. Experiments were tried in 1913, 1914, 1915, and 1916. (4) If single ascospores are planted in nutrient agar, each germinating ascospore will produce a colony having pycnidia and spores similar to *Septoria ribis* in pure culture as

[1] Stone, R. E. Perfect stage of Septoria ribis. Phytopath. 6: 109. 1916.

[2] Lindau, G. Engler & Prantl's Nat. Fam. 1[1]: 424.

TABLE 1

Record of single ascospore cultures of Mycosphærella grossulariæ

YEAR	NUMBER OF ASCOSPORES PLANTED	NUMBER OF ASCOSPORES GERMINATED	RESULT
1913	50	23	Pycnidia in 20 days
1914	71	40	Pycnidia in 23 days
1915	30	18	Pycnidia in 19 days
1916	15	12	Pycnidia in 24 days
Total......	166	93	93 colonies of Septoria

obtained from spores of *Septoria ribis* direct (table 1). Furthermore, the Septoria so obtained is capable of infecting *Ribes nigrum* causing the typical leaf spots from which the Septoria may be isolated.

Pammel[3] has suggested that *Sphærella grossulariæ* (Fr.) Auserw. is the perfect stage of *Septoria ribis* Desm., or of *Cercospora angulata* Wint., but presents no proof further than the association of the ascomycete with over-wintered currant leaves.

As far as can be learned at the present time *Mycosphærella grossulariæ* (Fr.) Lindau, has been collected in America only on *Ribes nigrum* by Pammel, Iowa, 1891,[4] W. A. McCubbin, St. Catharines, Ontario, April, 1915, and by the author at Guelph, Ontario, April and May, 1913, April to July, 1914, April to June, 1915, April to June, 1916. In Europe there are records of *Mycosphærella grossulariæ* on *Ribes grossularia* (original host), *Ribes nigrum* and possibly *Ribes rubrum*.[5]

That the fungus attacking *Ribes nigrum* is the same as that on *R. grossularia* and *R. rubrum* is shown by inoculation experiments with both ascospores and conidia (table 2).

A careful examination of the literature and collections gives the following synonymy and description of the fungus:

Mycosphærella grossulariæ (Fr.) Lindau, Engler and Prantl, Nat. Pflanzenfam. **1'**: 424.

Sphæria grossulariæ Fr., Syst. Myc. **2**: 521.

Sphærella grossulariæ (Fr.) Auserw., Syn. Pyr. Eur., 11.

?*Sphaeria ribis* Fckl., Sym. Myc., 108, Lille, p. 94.

Septoria ribis Desm., Mem. Soc. Sci., 1842.

Ascochyta ribis Lib. Ex. No. 53.

Phleospora ribis West. Bull. Acad. Sci. Brux., 1850.

Septoria grossulariæ auct. not *S. grossulariæ* (Lib.) West.

[3] Pammel, L. H. Iowa Agr. Exp. Sta. Bul. 13: 67-70.

[4] Ellis & Everhart. North American Pycenomycetes, p. 266; Pammel, L. H Iowa Agr. Exp. Sta. Bul. 13: 67-70; Stevens, F. L. Fungi which cause plant diseases p. 245 and 519.

[5] Saccardo, P. A. Syl. Fung. **1**: 486.

Perithecia mainly hypophyllous, somewhat gregarious, spherical, 60–105 μ diam., with a small papilliform osteolum, black; asci, eight-spored, short pedicellate, clavate to cylindrical, 50 to 60 x 8 to 14 μ; without paraphyses; ascospores slender, straight or slightly curved, 1-septate, each cell biguttulate until near maturity, hyaline, 28 to 35 x 3 to 4 μ, tending to appear in sets of 4 in the ascus. On dead over-wintered leaves of currant and gooseberry following *Septoria ribis* Desm.

Pycnidia mainly hypophyllous, sometimes amphigenous, variable in size, brownish black, spherical; conidia elongated, 2- to 3-septate, hyaline

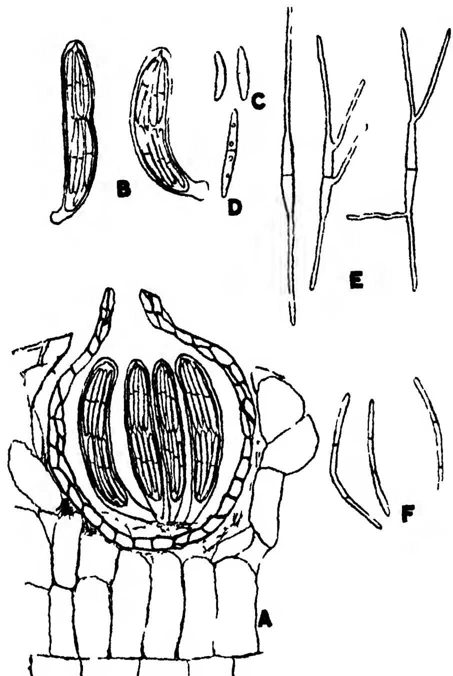

FIG. 1. Mycosphærella grossulariæ (Fr.) Lindau. × 280. *A*, perithecium containing asci; *B*, asci; *C*, young ascospores, *D*, mature ascospore; *E*, germinating ascospores; *F*, spores of Septoria ribis Desm

40 to 50 x 1 to 2 μ. Spots hypophyllous, dark ashy gray with a distinct margin, angular or oval.

Hosts—*Ribes nigrum*, *R. rubrum*, *R. grossularia*, *R. cynosbati*; also reported on *R. prostratum*, *R. rotundifolia*, *R. bracteosum*, *R. divaricata* (?).

In the synonymy *S. ribis* Fckl., has been included provisionally because *R. rubrum* is a host for *Septoria ribis* and because of certain discrepancies in Fückel's original description which make his measurements

TABLE 2

Inoculation experiments with Mycosphærella grossulariæ

INOCULUM AND SOURCE	DATE	TRIAL HOST	RESULT
Ascospores from R. nigrum	May 31, 1915	R. nigrum	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. rubrum	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. grossularia	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. oxycanthoides	Spots June 18, pycnidia
Ascospores from R. nigrum	May 3, 1916	R. nigrum	Spots May 25, pycnidia May 30
Ascospores from R. nigrum	May 31, 1915	R. aureum	
Ascospores from R. nigrum	May 3, 1916	R. aureum	
Septoria from R. nigrum	Aug. 10, 1915	R. nigrum	Spots Sept. 1, pycnidia Sept. 7
Septoria from R. nigrum	Aug. 10, 1915	R. grossularia	Spots Sept. 1, pycnidia Sept. 8
Septoria from R. nigrum	Aug. 10, 1915	R. rubrum	Spots Sept. 1, pycnidia Sept. 9
Septoria from R. nigrum	Aug. 10, 1915	R. aureum	
Septoria from R. nigrum	July 22, 1916	R. nigrum	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. rubrum	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. grossularia	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. oxycanthoides	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. aureum	

untrustworthy and because the thickness of the ascus wall would indicate that he was dealing with an immature ascus. Under such conditions the fungus might well conform to *M. grossulariæ* (Fr.) Lindau.[6]

Septoria grossulariæ auct., is included in the synonymy because many of the numbers so marked in American exsiccati agree with *S. ribis* Desm., in spore measurements besides occurring on a host of that fungus,[7] and do not at all agree with *S. grossulariæ* (Lib.) West., which has spores measuring 16 by 1 μ.

SEPTORIA AUREA E. & E.

In 1893 Ellis & Everhart described the Septoria occurring on *Ribes aureum* as a new species, *S. aurea.*[8] They also described a variety on the same host as *S. aurea* var. *destruens*, differing from the type by having longer spores.

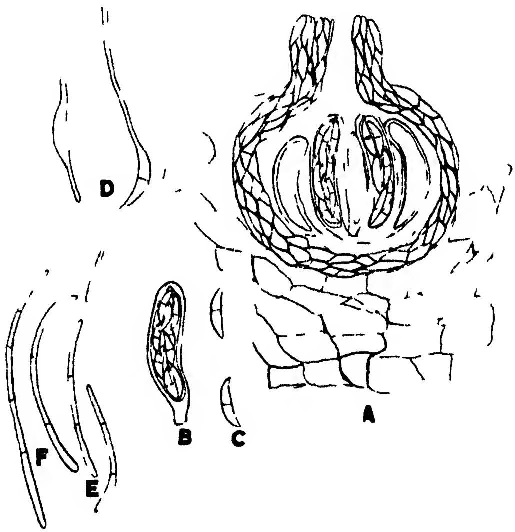

FIG. 2. Mycosphaerella aurea Stone × 280 *A*, perithecium with asci; *B*, ascus; *C*, ascospores; *D*, germinating ascospores; *E*, summer spores of Septoria aurea E. & E.; *F*, spores from a winter pycnidium

Septoria aurea E. & E. is the cause of a leaf spot on *Ribes aureum* Pursh. The spots are first noticed in June and continue until the leaves are shed in the autumn. The spots are oval or round, light brown in color with

[6] Fuckel. Symb. Myc. Eur., p. 108.

[7] Seymour and Earle. Economic Fungi, 473: Ellis & Everhart Fungi Columbiani, 845 2172, Ellis & Everhart. North American Fungi, 3373, 11480; Ellis & Everhart. Fungi Columbiani, 4478, on *Ribes lacustre* may be another species

[8] Saccardo, P. A. Syl. Fung. 11: 541.

a distinct, darker brown margin. The spots are 3 to 10 millimeters in diameter, sometimes confluent. Pycnidia amphigenous, 80 to 120 μ in diameter, walls thin. Early in the season the spores are comparatively small being 30 to 55 by 1.5 to 2 μ, but later in the season, especially after dry weather, the spores may measure, up to 75 by 2 to 2.25 μ. The form with the larger spores was described as *S. aurea* var. *destruens* E. & E.

After the fall of the leaves the fungus continues development and very generally passes the winter in the imperfect stage. The old leaves become more or less blackened and bear, generally on the under surface, numerous black thick-walled pycnidia. These pycnidia are 100 to 160 μ in diameter. The walls are 25 to 30 μ in thickness and are composed of numerous layers of cells. The spores are hyaline, measure 70 to 115 by 2 to 3 μ and are 3- to 5-septate.

The perfect stage

The old leaves also bear an ascomycete of the Mycosphærella type which by inoculation (table 3), and by pure culture (table 4), has been shown to be the perfect stage. As this stage apparently has not been described the following name is proposed and a description appended.

Mycosphaerella aurea n. sp.[9]

Syn. *Septoria aurea* E. and E.
Septoria aurea var. *destruens* E. and E.
Exs. Ellis and Everhart, North American Fungi, 2844.
Ellis and Everhart, Fungi Columbiani, '844, 1779.
Seymour and Earle, Economic Fungi, 472.

Perithecia amphigenous, partially embedded in leaf tissue, globose, short, papilliform, black, 75 to 115 μ in diameter; walls pseudoparenchymatous, two or three layers of cells thick; without paraphyses; asci subclavate to cylindrical, short stipitate, eight-spored, 50 to 75 μ; ascospores hyaline, of two equal cells, fusoid, curved, pointed at each end, 18 to 24 by 3 to 4 μ, irregularly biseriate.

Pycnidia amphigenous on definite spots when occurring on living leaves, 80 to 120 μ in diameter; spores hyaline, 30 to 75 by 2 to 2.25 μ, 3- to 5-septate. Pycnidia, in winter condition, amphigenous, 100 to 160 μ in diameter, thick-walled; spores hyaline, 70 to 115 by 2 to 3 μ.

Perithecia appearing on old leaves of *Ribes aureum* Pursh. May to June.

Pycnidia appearing on living leaves of *R. aureum*. June to October, and also on old leaves in winter and spring until June.

[9] If Sphærella is considered *nomen conservandum* the combination should be *Sphærella aurea* n. sp.

Kansas, Wisconsin, New York, Ontario.

Type material deposited in Cryptogamic Herbarium of the New York Botanical Gardens, New York City, supplemental material in the National Herbarium at Washington, D. C.

Mycosphaerella aurea spec. nov.

Syn. Septoria aurea E. and E.
Syn. Septoria aurea var. *destruens* E. and E.
Exs. Ellis and Everhart: North American Fungi, 2844.
Ellis and Everhart: Fungi Columbiani, 844, 1779.
Seymour and Earle: Economic Fungi, 472.

Fungus ascophorus: Perithiciis amphigeniis, erumpentibus, gregariis, sphæropsoidiis, atris, ostiolo brevi atque pertuso; ascis brevissime stipitatis, subclavatis vel cylindratis, 50 to 75 x 12 to 14 μ, 8-sporidiis; sporidiis hyalinis, fusoidiis, curvatis, extremitate utraque acuta, 18 to 24 x 3 to 4 μ, non in medio constrictis, distichis.

Hab. in foliis emortuis Ribis aurei, Ontario, May–June, socii Septoria aurea E. & E.

Fungus imperfectus: In foliis vivis maculis, determinatis, amphigenis, rotundatis vel confluentibus, atrozonatis; picnidiis amphigenis, 80 to 120 μ in diam.; sporulis 30 to 75 x 2 to 2.25 μ, hyalinis, 3- 5-septatis. Picnidiis in foliis mortuis; in maculis amphigenis gregariis, atris, 100 to 160 μ; vallo 10 to 15 cellis crasso; spordulis hyalinis, 75 to 115 x 2.3 μ, 3- 5-septatis.

In foliis vivis Ribis aurei, May-Oct., Kansas, Wisconsin, New York, Ontario. In foliis mortuis Ribis aurei, Nov.-June, Ontario.

That *Mycosphærella aurea* Stone is the perfect stage of *Septoria aurea* E. & E. is indicated by the following data:

Mycosphærella aurea has been found only on old leaves of *Ribes aureum*, which had previously borne *Septoria aurea* in 1915 and in 1916.

Leaves of *R. aureum* bearing *S. aurea* placed out of doors in cages in 1915, developed *M. aurea* in spring of 1916.

The Septoria obtained from individual ascospores produced a dark compact colony with numerous closely aggregated pycnidia; spores hyaline, 30 to 60 by 2 μ, three to five-septate (table 4). The pycnidia mature in about twenty days. The Septoria is capable of infecting *R. aureum* but not *R. nigrum*, as was determined by inoculation experiments from cultures secured in 1915 and in 1916 (table 3).

To further determine the range of *Septoria aurea* a series of cross inoculations was performed with spores directly from the leaf spots on *Ribes aureum* (table 5).

TABLE 3

Inoculation experiments with Mycosphærella aurea

INOCULUM	DATE	TRIAL HOST	RESULT
Ascospore of M. aurea	May 10, 1915	R. aureum	Spots bearing pycnidia June 2
	May 10, 1915	R. nigrum	
	May 17, 1915	R. aureum	Spots and pycnidia June 10
	May 17, 1915	R. nigrum	
	May 15, 1916	R. aureum	Pycnidia June 4
	May 15, 1916	R. nigrum	
	May 15, 1916	R. rubrum	
	May 15, 1916	R. grossularia	
	May 15, 1916	R. cynosbati	

TABLE 4

Records of single ascospore cultures of Mycosphærella aurea

NUMBER OF ASCOSPORES PLANTED	DATE	NUMBER OF ASCOSPORES GERMINATED	
21	May 17, 1915	10	10 colonies Septoria
30	May 15, 1916	20	20 colonies Septoria

TABLE 5

Cross inoculation experiments with Mycosphærella aurea

SOURCE OF INOCULUM	TRIAL HOST	DATE	RESULT
R. aureum	R. aureum	July 6, 1916	Septoria July 20
	R. nigrum	July 6, 1916	
	R. rubrum	July 6, 1916	
	R. grossularia	July 6, 1916	
	R. cynosbati	July 6, 1916	

It is thus seen that *M. aurea* Stone, is the perfect stage of *Septoria aurea* E. & E., and that the fungus is limited in its range of hosts.

CONCLUSIONS

Mycosphærella grossulariæ (Fr.) Lindau is the perfect stage of *Septoria ribis* Desm.

The perfect stage has been reported on *Ribes grossularia* and *R. nigrum* in Europe and possibly on *Ribes rubrum*. In North America the perfect stage has been collected only on *Ribes nigrum*.

The imperfect stage has long been known as *Septoria ribis* and is known in Europe and North America. The following hosts are known from inocu-

lation experiments: *Ribes nigrum*, *R. grossularia*, *R. rubrum*, *R. cynosbati*. It has also been collected on the following hosts: *R. rotundifolia*, *R. prostratum*, *R. bracteosum* and *R. divaricata*.

Mycosphærella aurea Stone is the perfect stage of *Septoria aurea* E. & E. This fungus is more limited in its range being known only in North America on *Ribes aureum*.

Finally, the author wishes to thank those who have assisted in the work, especially Professors G. F. Atkinson and H. H. Whetzel of Cornell University, and Professor J. H. Faull of the University of Toronto for the use of their herbaria and libraries, and Dr. V. B. Stewart for help in looking up some of the literature.

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A METHOD FOR STUDYING THE HUMIDITY RELATIONS OF FUNGI IN CULTURE

NEIL E. STEVENS

Accurate studies of the temperature relations of certain fungi causing storage rots have been made by several investigators. The perhaps equally important question of their relation to air humidity or amount of evaporation has, on the other hand, been almost entirely neglected. This discrepancy is apparently due to the fact that reliable thermostats, at least for temperatures considerably above and below room temperature, are available in nearly all laboratories, and the thermometer furnishes a satisfactory means of temperature measurement. The control of air humidity in large chambers is, on the other hand, relatively difficult and expensive. The considerable recent literature discussing the rate of evaporation shows how leading authorities differ as to the best method of measuring this factor, and it is perhaps equally debatable whether any really accurate and satisfactory method of recording air humidity is available (10).

During investigations of the fungi causing decay of strawberries in transit and more recently in studying the rots of cranberries, the writer has made use of a method of maintaining known humidities in small chambers which is applicable to the study of fungi in culture or growing on small fruits.

The method used was suggested to the writer by Dr. Charles Thom, and published by him in 1915 (12: 304). No claim to originality is, of course, made by the writer. The method is, however, described somewhat fully, because it seems applicable to much wider use. The table represents a compilation from the most reliable sources, and since so far as could be learned it is nowhere available as a whole, is here published for the convenience of other investigators. In compiling this table and in locating the sources on which it is based the writer has had the advice and assistance of several physiologists and physicists, to all of whom he wishes to acknowledge his indebtedness.

METHOD

Briefly, the method consists in keeping the cultures of fungi or affected fruits in an atmosphere which is maintained at a constant humidity by exposure to aqueous solution of sulphuric acid of known specific gravity.[1]

[1] This method of maintaining a constant humidity has been employed by Curtis (3) in his studies of the insulating properties of hard rubber and other solid dielectrics. This writer published (3 : 367) a curve showing the relationship between

Other hygroscopic substances might be used to maintain a constant humidity but sulphuric acid is convenient to use and so slightly volatile that it apparently does not affect the growth of the fungus.

The specific gravity of the solution was determined with a hydrometer when the temperature of the acid was 0°C. This temperature was easily maintained by using ice in diluting the acid, as suggested by Hastings (8). In practice the writer has found it convenient to use Hempel desiccators as containers. This form of container permits of readily changing the acid without disturbing the cultures or fruit, while the acid is free from contamination by juice leaking from berries or other fruits.

TABLE

The table showing the approximate relative humidity and saturation deficit corresponding to aqueous solutions of sulphuric acid of various specific gravities is based on the best information available. All computations were made with the aid of Crelle's multiplication tables (2) and carried to the first decimal place. They are, therefore, not absolutely accurate to the last figure but are well within the limits of observational error and will be found satisfactory for experimental work.

The portion of the table which includes specific gravities from 1.00 to 1.30 was taken in part from the similar table published by Hastings (8) which in turn was based on the experimental work of Dieterici (5). The relative humidity for each specific gravity of acid was taken from Hastings' table and the vapor tension at 20° and 30°C. calculated, on the assumption that the relative humidity for a given specific gravity of acid remains the same at all climatic temperatures, by multiplying the relative humidity by the vapor pressure of water at the given temperature. The saturation deficit, of course, is the difference between the vapor pressure of water and of the solution. The column giving the percentage of H_2SO_4 in the solution was added from Castell-Evans' physico-chemical tables (1: 843 and 861).

The second section of the table, including specific gravities from 1.344 to 1.754 is based on the work of Sorel (11), whose table gives the tension of aqueous vapor emitted by aqueous solutions of sulphuric acid containing various percentages of H_2SO_4. His table with the addition of a column giving the specific gravity for each percentage of acid is reprinted in the Chemiker Kalender (11). In this portion of table 1 the saturation deficit and approximate relative humidity have been added from calculations.

the density of a sulphuric acid solution and the relative humidity which will be maintained by it in an inclosure. This curve corresponds approximately to data given in table 1.

Table showing approximate relative humidity, vapor pressure and saturation deficit at 20° and 30°C. for dilute sulphuric acid of various specific gravities

SPECIFIC GRAVITY	PERCENTAGE H_2SO_4 IN THE SOLUTION	APPROXIMATE RELATIVE HUMIDITY	VAPOR PRESSURE AT 20° C.	SATURATION DEFICIT AT 20° C.	VAPOR PRESSURE AT 30° C.	SATURATION DEFICIT AT 30° C.
		per cent	*mm. of mercury*		*mm. of mercury*	
1.00	Water	100	17.39	0.0	31.55	0 0
1.01	1 57	99 5	17.3	0.1	31.4	0 1+
1.02	3.03	99.1	17.2+	0.2−	31 3	0.2
1.03	4.49	98 7	17.2−	0.2+	31 1	0.4
1 04	5.96	98.2	17.1	0.3	30.9	0.6
1.05	7.37	97.5	17.0	0.4	30.7	0.8
1.06	8 77	96 9	16.9	0 5	30 5	1 0
1 07	10.19	96.2	16 7	0 7	30.3	1.2
1.08	11.6	95.6	16.6	0 8	30.1	1 4
1.09	12.99	94.8	16.5	0 9	29.9	1 6
1.10	14.35	93.9	16.3	1 1	29.6	1.9
1.11	15.71	93 2	16 2	1.2	29.4	2 1
1.12	17.01	92.3	16.1	1.3	29.1	2 4
1.13	18.31	91 2	15.9	1.5	28.7	2 8
1 14	19.61	89.9	15 6	1 8	28.3	3 2
1.15	20.91	88 8	15 4	2 0	28.0	3.5
1.16	22.19	87.4	15.2	2 2	27.5	4.0
1.17	23.47	85 7	14.9	2 5	27.0	4 5
1 18	24.76	84.0	14 6	2.8	26.5	5.0
1.19	26.04	82.3	14 3	3 1	25.9	5 6
1 20	27.32	80.5	14 0	3.4	25.4	6 1
1.21	28.58	78 7	13.7	3.7	24.8	6 7
1.22	29.84	76.7	[illegible]	4.1	24.2	7 3
1.23	31.11	74.6	[illegible]	4.4	23.5	8.0
1 24	32.28	72.5	12.6	4 8	22.8	8.7
1.25	33.43	70.4	12.2	5.2	22.2	9.3
1.26	34.57	68.0	11 8	5 6	21.4	10.1
1.27	35.71	65.5	11.4	6.0	20 6	10.9
1.28	36.87	63.1	11 0	6.4	19.9	11.6
1.29	38.03	60.7	10 6	6 8	19.1	12.4
1.30	39.19	58.3	10.1	7.3	18.4	13.1
1.344	44.0	49.0	8.5	8.9	15.5	16.0
1.361	46 0	45.0	7.7	9.7	14.5	17.0
1 380	48.0	42.0	7.1	10.3	13.4	18.1
1 398	50.0	38.0	6.5	10.9	12.0	19.5
1.417	52.0	33.0	5.8	11.6	10.9	20.6
1.438	54.0	29.5	5.0	12.4	9.5	22.0
1.459	56.0	25.0	4.3	13.1	8.1	23.4
1.479	58 0	21.5	3 5	13.9	7.2	24.3
1.503	60.0	18.5	3.0	14.4	6.1	25.4
1.524	62.0	15.5	2.6	14.8	5.0	26.5
1.546	64.0	12.7	2.2	15.2	4.0	27.5

Table showing approximate relative humidity, vapor pressure, and saturation deficit at 20° and 30° C. for dilute sulphuric acid of various specific gravities.—Continued

SPECIFIC GRAVITY	PERCENTAGE H_2SO_4 IN THE SOLUTION	APPROXIMATE RELATIVE HUMIDITY	VAPOR PRESSURE AT 20°C	SATURATION DEFICIT AT 20°C	VAPOR PRESSURE AT 30°C.	SATURATION DEFICIT AT 30°C
		per cent	*mm of mercury*		*mm of mercury*	
1 569	66 0	10 5	1 8	15 6	3 5	28 0
1 592	68 0	9 0	1 5	15 9	3 0	28 5
1 615	70 0	7 5	1 3	16 1	2 5	29 0
1.639	72 0	6 0	1 0	16 4	2 0	29 5
1 662	74 0	4 5	0 6	16 8	1 7	29 8
1 690	76 0	3 5	0 5	16 9	1 4	30 1
1 710	78 0	3 0	0 4	17 0	1 1	30 4
1 732	80 0	2 5	0 3	17 1	0 8	30 7
1 754	82 0	1 5	0 2	17 2	0 5	31 0

SATURATION DEFICIT AND RELATIVE HUMIDITY COMPARED

The point has been frequently raised (4: 64–68; 9: 114; 8: 2–7) that saturation deficit, i.e., the difference between the observed vapor pressure and the maximum vapor pressure possible at the same temperature, is a more satisfactory expression of atmospheric humidity than is relative humidity, i.e., the ratio between the observed vapor pressure and the vapor pressure at saturation under the same conditions of temperature. The relation between these two expressions is discussed by Hann (6: 49; 7: 161) and illustrated as follows. If E denotes the vapor pressure at saturation, e the observed vapor pressure, the relative humidity is the quotient of $e \div E$ and the saturation deficit the difference, $E - e$. The saturation deficit is therefore equal to $(1-\text{relative humidity})E$. Evidently, then, for the same relative humidity the saturation deficit increases with the temperature, because E(vapor pressure at saturation) increases very rapidly with the temperature.[2] Meyer (9: 115) and Deneke (4: 68) give tables by means of which the saturation deficit can be derived from air temperature and relative humidity.

It is correctly urged by the advocates of saturation deficit that a given percentage of relative humidity, for instance, 75, has very different meanings when the temperatures differ, and in order for relative humidity to have any real significance it is always necessary to take into account the temperature prevailing at the time. In saturation deficit the factor

[2] Hann (6: 48–49) points out that by fortunate coincidence in the case of temperatures usually occurring out of doors the vapor pressure in millimeters and the weight of water vapor in grams per cubic meter are expressed in almost the same figures. If this is true, it is evident that saturation deficit as given in table 1 may be considered as roughly indicating the weight of water in grams which a cubic meter of air lacks of saturation The approximation is closest at 20°C.

of temperature is included and rapidity of evaporation is much more nearly proportional to the saturation deficit than to the relative humidity.

On the other hand, Hann (6: 47–66) contends that relative humidity is preferable as a means of expressing climatological facts, because it is more readily understandable and has a closer relation to physiological reaction. From the context it is evident that he refers to human physiology and is evidently using the term to include psychological and temperamental relations. It is, however, not yet certain that the effect of atmospheric moisture even in plant physiology is entirely a matter of rate of evaporation. Perhaps, therefore, it would be well to follow Hann's suggestion and retain for the present both expressions, meanwhile trying to determine which one more nearly expresses the relation of plant processes to the moisture of the air. The fact should be constantly borne in mind that relative humidity without the corresponding temperature data is practically meaningless and in studies of plants, temperatures should always be given.

FRUIT DISEASE INVESTIGATIONS
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A PYTHIACYSTIS ON AVOCADO TREES

HOWARD S. FAWCETT

In May, 1914, part of a diseased trunk of an avocado tree was received from K. A. Ryerson, a student at the University of California, with a request for information regarding the nature of the trouble. The bark was killed and slightly sunken over an area twenty centimeters in length and seven centimeters (one-half the circumference) in greatest width. A gum had exuded and hardened in small beads on the surface, and in addition a white, powdery, crystalline substance was deposited over the surface at the lower part and below the diseased area. The freshly killed bark and wood were still firm, not soft or watery. The wood was affected only a few millimeters entad. This was typical, as was afterwards learned, of a bark disease occasionally occurring on avocados in a number of localities. The following information regarding its occurrence was obtained from Mr. Ryerson. The disease occurs most often on the trunk not far from the surface of the soil, but occasionally it is found higher on the trunk and also on limbs where it commonly begins at the base of a leaf. It occurs not only on the trunks of larger trees, but is found on small seedlings especially if they have been overwatered. This disease, while not of frequent enough occurrence to result in serious damage unless on particularly valuable trees, is likely to appear suddenly and spread fairly rapidly in spite of care exercised to check it.

Three culture tests were made from this specimen received from Mr. Ryerson, by first flaming the surface, then cutting off the outer bark, flaming again, cutting out small bits of the bark and wood from the junction of the dead and live tissue, and dropping them into slant corn meal agar tubes. A species of Pythiacystis developed in the three tubes.

In July, 1914, another specimen of an affected avocado limb which had been unsuccessfully treated by cutting away the diseased bark and disinfecting the area, was sent from the same locality. The bark had begun to heal at the cut edges, but the wood underneath was dark in color. The same fungus was again isolated from three different places in the darkened wood five millimeters from the surface and in one case ten centimeters beyond the point where the bark had been cut away for treatment. In five out of six tubes, made as before, a Pythiacystis developed.

On October 6, 1914, the trunks of two Mexican seedling avocado trees at the Whittier Laboratory were inoculated with this species of Pythiacystis by inserting into longitudinal cuts, two centimeters long, bits of the mycelium from a culture. The cuts were then covered with paraffined paper which were held with raffia. On one tree a cut of the same kind was made and covered as the others to serve as a check.

When the inoculated trunks were first examined on October 22, 1914, a watery, slightly colored liquid was exuding from both cuts, and below one lesion the white crystalline substance, seen on the original specimen, was being deposited as the exuding liquid dried. The check cut was already beginning to heal without any deposit.

On January 14, 1915, a considerable deposit of the white crystalline substance had formed at both of the inoculated cuts and the larger area of killed bark was two centimeters wide and six centimeters long. The wood was affected only a few millimeters in depth. The affected bark and wood was cut out to save the trees and four culture tests made as described before from the advancing edge of one of the diseased areas. In three of the culture tubes a Pythiacystis developed. The incision on the check tree healed rapidly without apparent injury to the adjoining bark.

One of the original cultures was kept alive by subcultures, and on March 28, 1916, further inoculations were made into avocado trunks with it and also with *Pythiacystis citrophthora* S. & S. isolated from the bark of a lemon tree affected with gummosis. Two inoculations from each culture were made and two additional cuts were made to serve as checks. All were wrapped in the same manner as in the previous inoculations. All inoculated cuts were showing the white crystalline deposit by April 7, 1916, and the bark about the cuts was discolored. On May 15, a large deposit of this white substance had formed below all the inoculated cuts. The effect on avocado of the Pythiacystis from lemon was about the same as of the species of Pythiacystis affecting avocado. A diseased area of each kind was cut out. They showed the cambium killed over an area two centimeters wide and five centimeters long. The avocado Pythiacystis was again recovered from the advancing edge of a diseased area. The cuts serving for checks healed rapidly without apparent injury to the tree.

The same two cultures were tested on young orange trees at the same time. The lemon Pythiacystis produced gummosis on the orange with killing of bark adjacent to the cut. The avocado Pythiacystis, however, produced no effect, the cuts healing almost as rapidly as the checks.

That a Pythiacystis, similar to *Pythiacystis citrophthora*, may under certain conditions become at least a wound parasite of avocado trees, is shown by these tests. The fungus was isolated from two different

specimens, was grown in pure cultures, was introduced into trunks of avocado trees at two different seasons and produced effects similar to those on the trees from which it was isolated. It was twice recovered in cultures from the inoculated trees, in one case six weeks later and in another three months after the inoculation.

UNIVERSITY OF CALIFORNIA
GRADUATE SCHOOL OF TROPICAL AGRICULTURE
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SCLEROTINIA LIBERTIANA ON SNAP BEANS[1]

J. A. McClintock

WITH TWO FIGURES IN THE TEXT

Early in November, 1915, the Virginia Truck Experiment Station was notified of a rather serious loss in a fall crop of snap beans (*Phaseolus vulgaris*) on one of the large truck farms of this section.

There were thirty acres of beans in several fields on this farm. The fields were separated from each other by tall hedges. Over large areas in some of the fields no beans were picked because the plants had not developed sufficiently to produce marketable pods. On these stunted plants many small, withered or partly decayed pods more or less covered with white mycelium and small, hard, sclerotial masses were observed as shown in figure 1. Many of the plants also bore white mycelium and sclerotia on their stems and branches as shown in figure 2.

The beans were planted late in July between rows of strawberry plants and grew well until five or six weeks of age. At this time, i.e., early in September, there was a period of three or four days of hot, humid weather. Immediately following this period, in areas where the plants stood thickest, the plants began to show signs of trouble with withering and decay of stems, leaves and pods. The disease spread rapidly in the fields with the result that instead of getting six thousand baskets of beans, as expected, the total crop was about four thousand baskets.

Specimens of diseased plants were taken to the laboratory on November 9, 1915. Sections of diseased stems and pods were externally disinfected for five minutes in 1 to 1000 mercuric chloride, and then transferred to sterilized petri dishes. Lima bean agar was poured over these sections. On November 15, 1915, an organism, similar in appearance to the one on the bean plants, was obtained from a section of pod plated November 9.

INOCULATIONS ON LETTUCE

As the organism producing the abundant, black sclerotia in culture appeared similar to the organism which had previously been isolated from diseased lettuce (*Lactuca sativa*), inoculations with the organism

[1] While this work was in progress the writer was interested to see Dr. Barrus' article "An Anthracnose-resistant Red Kidney Bean" in Phytopathology 5: Nov. 1915, p. 303, in which he mentions *Sclerotinia libertiana* as the occasional cause, when the weather is especially favorable, of a brown rot of beans.

from beans were made on lettuce to see if it would produce typical lettuce drop. On November 27, 1915, with culture 1 the following inoculations were made: (1) Four large lettuce plants in individual pots were wounded on the stems just below the surface of the soil, and one sclerotium from culture was applied to each wounded stem and covered with soil. Similar plants were wounded and kept as checks. Both inoculated

Fig. 1. Diseased bean pods showing white mycelium and sclerotia of *Sclerotinia libertiana.*

plants and checks were placed in moist chambers. (2) One pot of twenty-five seedling lettuce plants was inoculated by placing one sclerotium on the soil between two plants. (3) Four large lettuce plants in individual pots were inoculated by slashing the stems at the surface of the soil and applying bits of mycelium to the wounded tissues. (4) Thirty seedling

lettuce plants in another pot were inoculated by placing bits of mycelium on the soil in contact with the stems. The plants of this second series were not covered with bell-glasses

The results were as follows (1) Of the four large lettuce plants inoculated with sclerotia, one plant showed typical drop on December 9, a second on December 10 and the remaining two on December 18. (2) All of the twenty-five seedling plants inoculated with sclerotia showed

FIG 2. Diseased bean plant showing mycelium and sclerotia of *Sclerotinia libertiana* on stem and branches

drop on December 10 (3) The four large plants inoculated with mycelium remained healthy (4) The thirty seedling plants inoculated with mycelium showed typical drop on December 13

In the case of the four large lettuce plants which were inoculated with mycelium but which were not placed under bell-glasses, it appears that the mycelium dried before it gained a foothold on the more mature tissues, the plants, therefore, remained healthy

As the check plants remained healthy, it appeared that the organism from the bean was probably a strain of *Sclerotinia libertiana* Fckl. because its effect on the lettuce plants and the production of typical sclerotia in the axils of the leaves were similar to those of *Sclerotinia libertiana.*

INOCULATIONS ON BEAN PLANTS

To determine whether or not this Sclerotinia was parasitic on beans the following inoculations were made: (1) On December 4, 1915, three bean plants, two weeks old, were inoculated from a sub-culture made November 26, 1915, by applying bits of mycelium to the slashed cotyledons. Two similar plants in the same pot were inoculated by applying bits of the fungus to the wounded stems at the surface of the soil. This pot of five plants was placed under a bell-glass. (2) Five bean seedlings in a second pot were treated as above except that the plants were not injured before applying bits of the fungus to stems and cotyledons. This pot was also placed under a bell-glass.

The five seedling bean plants of a third pot were slashed about the stems and cotyledons to serve as checks.

On December 7, 1915, one of the bean plants inoculated on the slashed cotyledon had become so badly decayed on the stem at that point as to topple over. Abundant white mycelium was present over the surface of the other bean plants at the points of inoculation. The host tissues at these points had become water-soaked in appearance.

On December 8, 1915, five days after inoculation, the two bean plants inoculated on the slashed stems and also the other two plants inoculated on the cotyledons had decayed at the points of inoculation and fallen over. On the same date two plants of pot 2 which were inoculated on the uninjured stems had also begun to decay at the point of inoculation. The pot of check plants showed no sign of disease.

These tests proved that the Sclerotinia obtained from bean plants from the field was pathogenic to both bean plants and lettuce plants, and it was concluded that it was this Sclerotinia which had produced the trouble in the bean fields.

On December 9, 1915, three five-days-old bean plants, growing in one pot, were inoculated by placing bits of the bean Sclerotinia in contact with the cotyledons which were just pushing through the surface soil. A similar pot of seedlings served as check. These two pots were not placed under bell-glasses.

On December 18, 1915, the three bean plants inoculated ten days previously had begun to decay at the base of the stem. The check plants remained healthy.

Comparing plants in this test with plants similarly inoculated but placed under bell glasses it is seen that it took twice as long for the same organism to produce decay when the inoculated plants were not placed under bell-glasses, thus indicating that humidity is an important factor in the spread of this organism.

During December, 1915, two more collections of specimens were made from the same farm. In each case, sclerotia removed from the diseased stems and pods when externally disinfected in 1 to 1000 mercuric chloride and plated on agar yielded the white mycelium and black sclerotia. Material from sub-cultures of the above placed in contact with the stems of seedling bean plants resulted in the typical decay. Reisolations from these artificially infected plants yielded a Sclerotinia similar to that obtained from the field plants.

It was noticed that in culture the sclerotia from the bean-disease fungus differed considerably in size and shape from sclerotia produced by the lettuce-drop organism. Further work is under way to determine whether or not there are similar differences between the ascosporic stages of these two organisms.

VARIETAL RESISTANCE

Two varieties of snap-bean seed were used on this farm, one a black seeded variety known under the trade name of Black Valentine, the other a red or spotted seeded variety, known as Red Extra Early Refugee.

According to the observations of the owner of the farm, the Red Extra Early Refugee was much more susceptible to this trouble, due, probably to its more rapid and tender growth. Artificial inoculation tests, however, proved that both varieties were readily attacked by the Sclerotinia isolated from the bean plants. Several other varieties of snap-bean seed have been obtained and tests are now being made to determine whether or not any of the varieties show marked resistance to this Sclerotinia.

Prior to planting the fields to a fall crop of snap beans, spring crops of snap beans and garden peas had been grown. These plants are known to be hosts of *Sclerotinia libertiana,* so the fungus was probably present here and there over these fields, in the form of sclerotia, awaiting suitable conditions for parasitic development.

There is reason to believe that in the warm, humid climate of eastern Virginia this organism may become a serious menace to snap bean growing unless the growers take steps to free their soil from it by proper rotation of crops.

SUMMARY

A serious disease in a fall crop of snap beans was found to be due to a Sclerotinia.

Cross inoculations proved that this Sclerotinia was able to produce typical lettuce drop.

The fungus required twice as long in dry air as in humid air to produce typical decay, thus showing that moisture is an important factor in its spread.

Some evidence of difference in varietal resistance was observed in the field.

In culture the Sclerotinia isolated from beans produced sclerotia which differed in size and shape from sclerotia produced in culture by the lettuce-drop organism, thus suggesting that the former organism is a special strain of *Sclerotinia libertiana* Fckl.

TRUCK EXPERIMENT STATION
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CITRUS SCAB

H. S. Fawcett

The writer wishes to discuss some features of Grossenbacher's article entitled, Sour scab of Citrus in Florida, and its prevention.[1]

One questions in the first place the advisability of ignoring the common names scab and verrucosis used by Swingle and Webber[2] and well established in the later literature on the subject, and of using the misleading term, sour scab. This name would seem to convey the impression that the disease tends to make fruit affected by it sour, or that it is confined to the sour orange or to very acid fruits, which is by no means the case. While the sour orange and lemon are, to be sure, two of the most susceptible varieties in Florida, the Satsuma orange is also susceptible. It would seem that common names of plant diseases well established in literature should not be changed without sufficient reason.

A discussion by Grossenbacher of the various possible factors related to the cause of scab, such as high acidity induced by wet, cold weather with resulting high osmotic pressure, exuded aromatic substances absorbed by films of water on the leaves, oil liberated from glands on the surface and so forth, is followed by the statement: "The tangible evidence in support of the idea universally held, that *Cladosporium citri* causes sour scab, is slight and inconclusive. In fact, the evidence to the contrary is even stronger."

In another place it is stated: "It is an interesting fact that sour scab has always been attributed to the fungus *Cladosporium citri*, and that some of the inoculation experiments performed by Fawcett upheld the assumption that this fungus is the cause of the disease, while others were either negative or neutral."[3]

Attention should be called to this "evidence to the contrary" presented in Grossenbacher's paper. It is stated first that a doubt developed during field observations in 1913–14 regarding the correctness of this "hypothesis"; then that inoculation tests repeated three times during three different growth periods in 1915 failed to produce a single indication of the disease on rapidly growing sour-orange and grapefruit seedlings.

It appears quite evident from another part of the paper, where statements are given of the appearance and occurrence of the fungus with

[1]Phytopath. **6** : 127–142, April, 1916.

[2]Swingle, W. T., and Webber, H. J. Principal diseases of citrous fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. Path. Bul. 8: 20–24. 1896.

[3]Fawcett, H. S. Citrus scab. Florida Agr. Exp. Sta. Bul. 109: 51–60. 1912.

which Grossenbacher was making these inoculation tests, that he was using the common saprophytic Cladosporium of the *C. herbarum* type, which is almost universally present on old scabs, instead of the less conspicuous, true scab fungus to be found on the early-stage scabs of the rapidly developing tissue. Grossenbacher apparently overlooked the fact that *Cladosporium citri* Massee, as described in cultures in Bulletin 109 previously referred to, is not an ordinary Cladosporium and is not what is ordinarily seen with the unaided eye on the old scabs. It was from the early stages, on which Grossenbacher states the fungus was usually not found, and not from the later ones, that I found it was possible to isolate *Cladosporium citri*. The Cladosporium on the older scabs which could be "selected with the unaided eye because of the dark-fruiting fungus," was, according to my experience, a pure saprophyte and not the fungus used in my inoculation tests. No mention is made of the fungus he had being an unusual Cladosporium, but emphasis is laid on the ease with which scabs could be selected with the unaided eye from which the Cladosporium he used could be isolated.

But even if the right fungus were isolated from the old scabs, the negative results of three different tests at three different times mean little without a statement of the conditions under which the inoculation experiments were made. In another part of the paper a great deal of emphasis (and that rightly) is laid on the special conditions necessary for the occurrence of scab. But in giving these negative results as evidence, the only condition stated is that the trees were growing vigorously. Some weight appears to be given to the fact that some of the results obtained by the present writer were negative. These negative results were included in the publication of the experiments in Bulletin 109 for what they were worth in indicating that at first only part of the conditions for infection in the greenhouse experiments were satisfied. At first negative results were obtained in spraying on spores from pure cultures, even though one of the necessary conditions for infection, vigorous growth, was satisfied. Later positive results were obtained under the same procedure, due it would seem to combining abundant moisture on the surface of the leaves with vigorous growth. The plants used as checks remained free from scabs in each case.

An experiment is also described in the paper by Grossenbacher under the discussion of the cause, in which sour orange trees were cut back and scrubbed with corrosive sublimate and then covered with cheese-cloth stretched about four stakes driven in the ground, the top and bottom also being covered with cheese-cloth. It is stated that the trees under the cheese-cloth had later practically as much scab on the leaves as the checks not covered. If this experiment were meant to have a bearing on the question of whether or not scab is due to an organism as

seems probable (otherwise the scrubbing with corrosive would scarcely have been necessary) it is difficult to see what value the experiment has in this connection. It is scarcely necessary to point out that the dimensions recorded for spores of *Cladosporium citri* Massee are such that 100 to 200 could pass abreast through a single mesh in ordinary cheesecloth without touching the threads on either side. And even assuming that cheese-cloth might be a partial filter for spores when dry, if the experiment were in the open the frequent rains of summer in Florida would carry innumerable spores through the meshes in drops of water.

It is difficult to ascertain from the experiments and observations presented in the paper, wherein the "evidence to the contrary is even stronger." That the "cause becomes obscured rather than clarified" in the mind of this author appears to be due to an oversight as to the true nature of the scab fungus and consequently to a failure to find or isolate the organism in the earlier stages of the scabs.

Cladosporium citri is not an ordinary Cladosporium, a fact I attempted to point out in some detail in Bulletin 109 of the Florida Agricultural Experiment Station. I considered at that time that Scribner had figured the right fungus and that Massee[4] had distinguished it from the other forms though both had confused the description in part at least with a saprophytic Cladosporium. A further study of this fungus in cultures is being made with the purpose of later placing it if possible more nearly in its proper relationship.

It may be of interest to note that some further very carefully controlled inoculation tests on sour-orange seedlings with pure cultures of this fungus, made subsequent to the publication of Bulletin 109 of the Florida Agricultural Experiment Station, have confirmed the results there reported. Ten trees were used in the experiment. Five trees used as controls were equal in age and growth to those inoculated. All were first sprayed with water. Then a camel's hair brush moistened with distilled water was drawn over the rapidly growing leaves of the check trees, and another camel's hair brush moistened with a suspension of spores from pure cultures of the fungus was drawn over the rapidly growing leaves of the others. In every other way the five check trees were treated in exactly the same way, tree for tree, as the inoculated ones. All trees were kept sufficiently well watered for normal growth. Two inoculated trees with their two corresponding checks were kept in a closed room of the greenhouse with high humidity and temperature between 20° and 35 C. A third tree and its corresponding check were covered 24 hours with bell jars after which they stood in a well ventilated greenhouse at

[4] Massee, G. Diseases of cultivated plants and trees. The Macmillan Company, New York, p 474 1910

15° to 30°C. A fourth tree and its corresponding check were covered with bell jars for 48 hours, after which they stood in front of a closed window of the laboratory at 15° to 28°C. A fifth tree and its check were kept outside under bell jars during the entire time of the experiment, but protected from the direct rays of the sun, at about 15° to 28°C. The leaves on each control had the same opportunity as the inoculated ones to be influenced by high acidity, high osmotic pressure, exuded aromatic substances absorbed by films of water on the leaves, oil liberated from the glands, etc., but not a single scab developed on their leaves. Those trees inoculated by drawing a camel's hair brush moistened with a water suspension of spores over their leaves, however, developed in from two to three weeks numerous typical scabs on which spores of the fungus were present in great numbers and from which pure cultures of the fungus were again obtained. The first indication of infection appeared in from six to eight days.

Grossenbacher's paper is valuable in calling attention in considerably more detail than previous papers to the special conditions and possible contributing factors influencing the occurrence and severity of scab. It also confirms the work of Swingle and Webber and others in showing that the disease yields readily to spraying with Bordeaux mixture, and also confirms some experiments of Yothers', published in the *Florida Grower*, in showing that lime-sulfur is also a preventive. The distinct contribution in his paper is the additional data obtained by a large number of spraying experiments with Bordeaux and lime-sulfur, as to the time when spraying is effective, the number of times necessary for efficient prevention and the actual losses from the disease in scabby fruits. These data are of great practical value.

Prof. Wm. T. Horne informed the writer that several years ago he had occasion to make some small studies on citrus scab. He writes "Trees of Dancy tangerine were readily infected in the greenhouse by placing material from scabs in drops of water on young leaves and covering the inoculated plants with bell-glasses. The plants were then kept very moist for several days. Typical scabs were produced, bearing spores characteristic of the so-called *Cladosporium citri*. No new scabs from natural infection were observed, although close watch was kept, the plants remaining in the greenhouse throughout the experiments. The inoculations were repeated several times with uniformly successful results and the material was then destroyed. Believing the relation of citrus scab and the so-called *Cladosporium citri* to be established and since the experiments were not planned to prove pathogenicity, no note was published of these studies."

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PHYTOPATHOLOGICAL NOTES

Pycnia of Cronartium pyriforme. So far as is known, the pycnia of *Cronartium pyriforme* (Peck) Hedgc. & Long have never been found.

On July 21, 1916, near Castella, Shasta County, California, at an elevation of 2200 feet, a few western yellow pine (*Pinus ponderosa* Laws.) seedlings and small saplings were found with typical, spindle-shaped or fusiform swellings on the main stem.[1] On one of these trees the aecia had already sporulated, while from two others drops of a Brazil-red,[2] clear, sweet, sticky liquid were exuding, which upon examination proved to contain innumerable pycnospores. There was no exudation from the swelling with the aecia. All these seedlings were standing within from one to five feet of *Comandra umbellata* bearing uredinia and telia.

The following description is based on field notes and the examination of collected material:

Pycnia caulicolous, scattered, subepidermal, forming small, bladder-like swellings, exuding a clear, sweet, sticky, Brazil-red liquid; pycnospores hyaline, commonly pyriform, (50) 3 to 4 by 3 to 7 μ (3 by 4).[3]

A certain analogy in the shape of the pycnospores and aeciospores is of interest. The great majority of the pycnospores were pyriform, even more truly so than the aeciospores, without taking on the extreme drawn-out, pointed shapes sometimes found in the latter. There was no reason to assume that this peculiarity of form could have been due to partial germination of the pycnospores. A few were ovoid or somewhat elongated.

The period elapsing between infection and appearance of pycnia and aecia will have to be exactly determined by artificial inoculations in the field but from the results of observation the following hypothesis may be advanced. In the region under consideration at the given elevation the aecia usually commence sporulation in late April or early May and finish by late June or early July, while telia on the Comandra are first sparingly produced in early July, do not become abundant until late July, and then continue until autumn. It seems, therefore, highly improbable that the

[1] Hedgcock, George G., and Long, William H. A disease of pines caused by Cronartium pyriforme. U. S. Dept. Agr. Bul. 247: 14. 1915.

[2] Ridgway, Robert. Color standards and color nomenclature, Plate I. 1912.

[3] Meinecke, E. P. Spore measurements. Science n. s. 42: 430. 1915.

pycnia found in this locality could have been the result of an infection by sporidia during the current season but more probably of at least one previous season. Since one tree was found on which the aecia had already sporulated but no pycnia were in evidence, and since the two trees with pycnia showed no signs of developing aecia, the assumption seems justified that the aecia do not appear until the season following the appearance of the pycnia. To sum up then, the pines are probably infected in the summer or fall of one season, pycnia do not appear until the summer of the next season at the earliest, while mature aecia are produced in the late spring or early summer of the third season. J. S. BOYCE

Phytophthora infestans on tomatoes in Australia.. The attention of the writer has been called by Dr. C. C. Brittlebank, of Melbourne, Australia, to an error of citation in a recent article by F. D. Kern and C. R. Orton[1] entitled "*Phytophthora Infestans* on Tomatoes." The citation in question is to the paper by N. A. Cobb, published in the Agricultural Gazette, N. S. W. **13**: 410–414, 1902. Dr. Brittlebank states that this paper by Cobb contains no report of Phytophthora so far as he can discover and he further states that the disease in question was not discovered on tomatoes in Australia until 1909 in Queensland, 1910 in New South Wales, and 1911 in Victoria. Dr. Brittlebank states that in Victoria the fruit is infected to a far greater extent than the leaves or stems. The citation was not taken from the original but from Bulletin 192 of the Virginia Agricultural Experiment Station, at the bottom of page ten. This note is written to correct this error so far as possible. C. R. ORTON

Leaf roll in tomatoes? At Lethbridge, Alberta, (Canada) test rows of tomatoes showed a phenomenon which closely resembled "leaf roll" in potatoes. The leaves of a number of plants showed a very pronounced "roll," while some plants of the same variety showed normal leaves only. The "roll" began from below and proceeded in an upward direction. The plants were trained on stakes and thus showed up well. Some years ago Dr. Gustav Kock[2] called attention to a similar occurrence in Austria. Dr. Köck failed to find any parasitic organism in his specimens; those at Lethbridge appeared sound with the exception of the rolling of the leaves (September, 1916). H. T. GÜSSOW

Celluloid cylinders for inoculation chambers. In the course of work on cultures of forest tree rusts and in inoculation experiments in general, it

[1] Phytopath. **6**: 284-287. 1916.
[2] Wiener landwirtschaftl. Zeitung, no. 89. November 8, 1911.

became evident that a substitute must be found to replace heavy bell-glasses and other similar vessels in isolating the inoculated plants. This was necessary since it was desired to supplement greenhouse work with experiments in the field, often on leaves, twigs, or branches of large plants. Inoculations of this nature barred the use of the ordinary methods

FIG 1. Celluloid inoculation cylinder

with heavy glassware. Entire immunity from exterior contamination was desired for that portion of the plant treated as well as the free entrance of light, a limited circulation of dust-free air, and the retention of a certain amount of moisture. To meet this demand cylinders of hard

clear glass were first employed[1] in a number of field experiments with much success. The method of procedure was the same as that described below for celluloid cylinders.

The increase in the number of experiments on the larger plants in the greenhouse made the cost of sufficient glass coverings prohibitive; also proper glass cylinders were found to be difficult to procure beside being easily broken. For inoculations on plants of different size and on parts of large plants a large number of cylinders of various dimensions were desired which should be flexible, transparent, non-fragile, and of light weight. Several devices were considered but none proved of any practical value with the exception of those cylinders made of ordinary sheet celluloid such as is used for windows in automobile tops and sold under the name of transparent celluloid. The thinner of the two grades of celluloid proved excellently adapted to the purpose in hand.

Cylinders of various lengths and diameters were made of this material, the edges being fastened together by means of acetic ether (ethyl acetate) applied by dipping a camel's hair brush in the liquid and running it quickly along the edges to be cemented. The acetic ether dissolves the celluloid sufficiently to form a tight joint when the liquid evaporates and if the two surfaces are kept pressed together until dry the resulting cylinders will be found to be durable.

These cylinders were slipped over branches and growing tips before inoculation, or over branches before the leaves appeared. The openings at either end were plugged with cotton and a small wad of moistened cotton was left on the branch inside the cylinder to provide sufficient moisture. Whenever necessary a split cedar splinter and a bit of string were used to support the cylinder with enclosed branch in its normal position. A small square of celluloid with a short piece of flexible wire attached can be cemented to the side of the cylinder and serve in place of a string. These formed ideal inoculation chambers (fig. 1) entailing small expense and labor and apparently interfering very little with the normal activities of the trial host. The usual care, however, must be exercised in regard to shading the inoculated plants when exposed to the direct rays of the sun. The greenhouse at Missoula where these cylinders were tried out is constructed with a roof having the south exposure of opaque material and letting in light only through the north side. They provided light, air, and sufficient moisture for successful inoculation, excluded troublesome insects and seed eating birds in the case of mistletoe experiments, and kept all other forms of inoculations and cultures successfully isolated.

[1] Weir, J. R. Phytopath. 5: 218, August, 1915.

Large cylinders covering the entire plant were made for use on herbaceous plants and tree seedlings and proved quite equal to and even better in some instances than large glass bell-glasses or large glass cylinders.

ERNEST E. HUBERT

Personals. The Department of Botany of the Massachusetts Agricultural College and Experiment Station has been reorganized with the following personnel:

A. Vincent Osmun, Professor and Head of the Department; George H. Chapman, Research Physiologist; P. J. Anderson, Associate Professor and Associate Pathologist; Orton L. Clark, Assistant Professor and Assistant Physiologist; F. A. McLaughlin, Instructor; G. W. Martin, Instructor.

LITERATURE ON AMERICAN PLANT DISEASES

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

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